APPENDIX B
COLUMBIA AND WILLAMETTE RIVER SEDIMENT QUALITY EVALUATION

Appendix B

Columbia and Willamette River Sediment Quality Evaluation for the Columbia River Channel Deepening Feasibility Report

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Columbia and Willamette River Sediment Quality Evaluation for the Columbia River Channel Deepening Feasibility Report

1.0 Introduction

The purpose of this report is to characterize the sediment of the Columbia and Willamette Rivers based on the sampling event described. Frequent reference will be made to the project "Sampling and Analysis Plan (SAP) for the Columbia River Channel Deepening" (Exhibit A) attached to this report and listed as a reference. The project description, site history and assessment are detailed in section 1 of the SAP. Previous sampling, also referred to in that section of the SAP, indicates that the bulk of the material evaluated, from the present 40-foot deep channel, has been found to be suitable for unconfined aquatic disposal, some material in the Willamette River would require further evaluation. Much of the material proposed to be dredged from the Willamette River channel-deepening project has not been evaluated previously.

The sampling and analysis objectives listed below are those stated in the (SAP) (sec. 2.0). This report will outline the procedures used to accomplish these goals.

SAMPLING AND ANALYSIS OBJECTIVES

The sediment characterization program objectives and constraints are summarized below:

- To characterize sediments to confirm or establish area rankings in accordance with the regional dredge material testing manual, the Dredge Material Evaluation Framework for the Lower Columbia River Management Area, November 1998 (DMEF).

- To provide information needed to develop a baseline cost estimate relative to proper disposal of dredged material.

- To provide information for the Columbia River Channel Deepening (CRCD) Environmental Impact Statement (EIS) sufficient to describe the material to be potentially dredged.

- Only physical and chemical characterization will be conducted. It is anticipated that additional chemical and biological testing shall be required prior to dredging commensurate with the proposed disposal method and DMEF.

In June of 1997 eighty-nine stations were sampled from the Columbia River channel, river mile (RM) 6.00 to RM 106.20, for physical analysis, of which, 23 were further analyzed for chemical contaminants. Sixty-eight samples were analyzed from 43 stations in the Willamette River, RM 0.10 to RM 11.55, for physical analysis, 45 (including replicate samples) were selected for chemical analysis. The following chemical tests were run on selected samples (see Tables 4-15); 9 inorganic total metals, polynuclear aromatic hydrocarbons (PAHs), total organic carbon (TOC), acid volatile sulfide (AVS), pesticides/polychlorobiphenyls (PCBs), Pore Water Tributyltin (TBT) and P450 Reporter Gene System (RGS), a dioxin/furan screen.

On September 14, 1998 surface grab samples were collected from 12 deep-water locations on the Willamette River. The purpose for collecting and analyzing these areas was to characterize the surface sediment at potential deep-water disposal sites in the Willamette River. Chemical analyses included metals (10), pore-water TBT, pesticides/PCBs, PAHs, phenols, phthalates, and miscellaneous extractables. Information is provided in tables 16-20, plates 26-27, and Exhibit B.

Exhibit B contains "Sediment Characterization Study of Local Sponsors' Berths; Columbia River and Willamette River Navigation Channel Deepening; Longview and Kalama, Washington and Portland, Oregon," Volume I, dated February 1, 1999. The purpose of the report was to provide preliminary dredge prism characterization of sponsor port facilities.

Purposed channel deepening from 40-feet to 43-feet would require disposal of the dredged material. In-water disposal of dredge material falls under the jurisdiction, of either, the Clean Water Act (CWA) or the Marine Protection, Research and Sanctuaries Act (MPRSA). An overlap of jurisdiction exists within the territorial sea (ref. DMEF page 20). This sampling event is not meant to be the final characterization of the sediment in the channel. Future characterization of the sediment may be required prior to any dredging. This report will characterize the sediment based on the current sampling event, but is not meant to make a final determination for future dredging disposal. In particular, areas with fine-grained sediments and areas that show contaminates above screening levels (SL), will be subject to further sampling and analysis. All sampling and analysis presently completed is (as future work will be) consistent with the laws regulations and guidance controlling this activity (for complete regulation overview see DMEF chapter 2).

2.0 Framework

The framework or basis of sediment sampling and analysis is consistent with an established national framework for the evaluation of environmental effects of dredged material disposal. This comprehensive evaluation framework, DMEF, governs sampling, sediment testing and test interpretation (disposal guidelines) for determining the suitability of dredged material. This ensures adequate regulatory controls and public accountability for disposal of sediment. The framework has been developed pursuant to the Clean Water Act of 1977 (Public Law 92-500), as amended, to the Marine Protection, Research and Sanctuaries Act of 1972 (Public Law 92-532), as amended, and to the national level dredging and disposal guidance developed subsequent to the passage of the laws (40 CFR 230-233; 40 CFR 220-229). Applicable national guidance documents include the jointly prepared Environmental Protection Agency/Corps of Engineers national framework entitled *Evaluation of Dredged Material Proposed for Ocean Disposal – Testing Manual*, dated February 1991 (referred to as the Ocean Testing Manual and also known as the "Green Book"), and the inland testing manual, entitled *Evaluation of Dredged Material Proposed for Discharge in Waters of the US – Testing Manual,* dated February 1998 (referred to as the "Inland Testing Manual").

The recent development of a regional DMEF has been the result of a cooperative interagency/intergovernmental program. It was established by the US Army Corps of Engineers (Corps), Region 10, US Environmental Protection Agency (EPA); Washington Department of Ecology (DOE), Washington Department of Natural Resources (DNR), and Oregon Department of Environmental Quality (DEQ) as principal agencies. These five agencies have regulatory and proprietary responsibilities for dredged material evaluation and disposal in the region. This group has developed a regional manual attempting to identify the most reliable, recognized, and cost effective sampling and analysis procedures for appropriately characterizing dredge material, and to incorporate these procedures into a document for application to the region. Chemical and biological tests and interpretation guidelines were developed for assessing the acceptability of dredged material for unconfined aquatic disposal. Application of these tests and guidelines will also provide preliminary information on the need for other disposal or management options, such as confined aquatic, nearshore, or upland disposal.

This regional framework document distills the accumulated knowledge and experience with dredged material management in the Pacific Northwest over the last 25 years. This document describes stepwise procedures for dredged material assessment and is intended for use by the regulatory community in the Lower Columbia River Management Area. Full consideration was made of all pertinent State and Federal laws, regulations, and guidance, including other regional dredged material management programs. The regional framework is consistent with the guidelines of the two national level manuals.

The procedures used in development of the manual were derived from, and inspired by, similar regional programs, including the successful Puget Sound Dredged Disposal Analysis (PSDDA) program for the Puget Sound region of the State of Washington, the Grays Harbor/Willapa Bay Dredged Material Evaluation Procedures Manual, and Portland District Corps of Engineers dredged material tiered testing procedures.

The goal of the manual is to provide the basis for publicly acceptable guidelines governing environmentally safe unconfined aquatic disposal of dredged material, thereby improving consistency and predictability in dredged material management. The establishment of evaluation procedures is necessary to ensure continued operation and maintenance of navigation facilities in the region, to minimize delays in scheduled maintenance dredging, and to reduce uncertainties in regulatory activities.

The tiered evaluation process outlined in the DMEF provides for physical and chemical evaluation in Tier II. The Tier III allows for bioassays both acute and chronic toxicity as well as bioaccumulative effects.

3.0 Previous Studies

As part of the Lower Columbia River Bi-State Program (referenced) sediment sampling and analysis was conducted, in 1991 and 1993, by Tetra Tech. A review of the sediment chemistry data from the Bi-State Reconnaissance survey relative to the federal Navigation Channel was made. No chemicals of concern above screening levels, established to evaluate the suitability of sediments for open water disposal, were detected in any sediment samples taken from the Federal Navigation Channel during the Bi-State survey. Only metals, no PAHs, PCBs, or pesticides, were detected in any sample collected from the channel. PAHs were found outside the channel in only 5 of 54 stations sampled and only one PCB, Aroclor 1254, was detected at one station. The Bi-State study did not conduct analyses for dioxin/furan in any sediment from the Federal Navigation Channel but limited their analyses to a select set of fine grained material samples. The Bi-State does not provide any evidence for dioxin/furan contamination of project sediments. The Corps as part of the November 1990 Columbia River Channel Deepening Reconnaissance Study (USACE, 1990) did collect sediment samples for dioxin/furan analyses from within the proposed channel alignment. Sample locations were chosen near discharges from pulp and paper mills in the Columbia River and select areas of the Willamette River. It was concluded that significant dioxin/furan contamination of the sediments within the Lower Columbia River portion of the project was not evident while further studies were recommended for the Willamette River.

The balance of evidence from previous sediment studies (1988, 1989, 1992 & 1996) of the lower Willamette River navigational channel shoals suggests that sampled shoals near the edges of the river contain more contaminates than those taken from the main channel areas. Most sediment sampled in these studies, with few exceptions, was found to be acceptable for unconfined open water disposal. The 1997-1998 "Joint DEQ/EPA Willamette River Investigation" confirm that nearshore areas, outside the navigational channel, contain much higher levels of contaminates than areas sampled within the proposed deepened navigational channel.

4.0 Ranking

Historical-sampling data from the Columbia and Willamette Rivers was used to rank the CRCD project area in accordance with the DMEF guidelines. The SAP (sec 3.1, Table 1&2) shows the present project area rankings and ranking description guidelines.

The historical data shows that the main stem of the Columbia River from river mile (RM) 5 to RM 74 and RM 88 to RM 99 have been given the "exclusionary" ranking. Exclusionary rank is coarse grain material (greater than 80% retained on a No. 230 sieve) with Total Volatile Solids (TVS) less than 5% and sufficiently removed from sources of sediment contamination. River mile RM 74 to RM 88 and 99 to 106 on the Columbia River was formerly ranked "low" in the draft DMEF has subsequently been ranked "exclusionary" in the final DMEF. This new ranking is based on data made available from this study. All the mainstem Columbia River navigational channel has been ranked "exclusive" based on data from this study.

Based on historical data the Willamette River has been ranked using the same DMEF criteria as the Columbia River. RM 0 to 3 and the O&M shoal at RM 8 to 10 are ranked "low" (see above explanation for, "low"). RM 3 to 10 were ranked "low-moderate" which means available data indicates a "low" rank, but there is insufficient data to confirm the ranking. The RM from 10 to 11.1 has been ranked "moderate" indicating that available data indicate chemical concentrations within a range associated historically with potential for causing adverse biological impacts. It could also receive this rank because sources exist in the vicinity of the project, or there are present or historical uses of the project site, with the potential for producing chemical concentrations within a range associated with some potential for causing adverse biological impacts. There are specific sites on the Willamette that have qualified for the "high" ranking. This means that known chemical sources, high concentrations of chemicals of concern, or significant responses in at least one of the last two cycles of biological tests. (When a "high" rank is indicated for an area based on preliminary data, the "high" rank is assigned to the area as a protective measure. That is, there is no rank of "high-moderate").

5.0 Sampling Event

Personnel from the US Army Corps of Engineers, Portland District (USACE) and National Marine Fisheries Service (NMFS) conducted the sampling event on the Columbia River, from June 2-5,1997, using their research vessel "Nerka". A Van Veen box core sampler was used to collect samples, from the surface up to 10" deep, from the Columbia River sediment. The samples were designated CR-BC-## (sequentially numbered).

The proposed sampling locations for the Columbia River Channel Deepening (CRCD) are contained in Appendix B of the SAP and listed in Table 1, of this report. The proposed location information was digitized from USACE, Portland District navigational charts and transferred into a Geographic Information System (GIS) database. The GIS database was converted to an ASCI format and the field was issued an electronic file and a hard copy of the location data. Due to program errors and incompatibility with the ships Global Positioning System (GPS) the electronic aid for sample site location was not used. As a result, there is some variation between the proposed sites and the actual sites. The Captain, using USACE, Portland District navigational charts with the proposed sampling sites marked and the calculated coordinates, navigated the actual sampling sites. Due to the program error, mentioned above, some of the calculated coordinates were in obvious error and did not match selected sites, marked on the charts. In these cases the Captain visually navigated to the chart location and then recorded the coordinates, from the onboard GPS, into the ship's log and marked the site on the navigational charts to verify actual locations. This accounts for variations between proposed and actual sampling locations. Actual sample locations are provided in this report, coordinates (Table 2) and site maps (Plates 1-27). Station locations on the Columbia River were chosen from shoal areas as indicated on the most recent Channel condition surveys performed by the USACE, Portland District Hydrographic Survey Branch (Table 3).

Station locations on the Willamette River were selected by Tom Rosetta of the Department of Environmental Quality (DEQ), Rick Vinning of Department of Ecology (DOE), and John Malek of the Environmental Protection Agency (EPA), Region 10 based upon shoals identified in the 1994 channel condition survey and proposed channel alignment. Sample locations are provided in this report, coordinates (Table 4) and site maps (Figure 2).

The Willamette River samples collected, July 22-25,1997, by Hart Crowser Inc., from Seattle Washington, were taken using two different sampling devices. The samples, surface to 10" deep, were taken with a Van Veen box corer and numbered sequentially using WR-BC-##

convention for shoals less than 3 feet thick. A 4" vibra core sampler was used for collecting the "GC" and the "CD" designated samples. When length permitted, the core was divided into 6' sections, the suffix designation of "A" for the surface to 6' segment, "B" for the 6' to 12' segment, etc. The "Z" sample represents the segment below the dredging prism. The "Z" samples, which would represent the new surface material (NSM), were submitted for physical analyses only.

Hart Crowser Inc. personnel supplied the following information on positioning for the Willamette River sampling event. GPS navigation was used for positioning the sampling equipment during the project. The system used was a Trimble Model 4000 DS GPS receiver. The GPS antenna was located on the sampling vessel on the A-frame above the pick point of the sampling device. A Trimble ProBeacon Coast Guard beacon receiver was used to provide differential corrections to the GPS. The accuracy of the ProBeacon corrections was better than +1 meter based upon on-site calibrations at the US Moorings dock on the Willamette River. The GPS receiver, set up on the survey vessel sent differentially corrected geographic positioning data to an integrated navigation software package called HYPACK. The software was installed on an 80486 DX33 PC with a 245-Mb hard drive. The GPS receiver displayed and transmitted data to an on-board computer in North American Datum 1983 geographic coordinates (latitude/longitude). HYPACK converted the North American Datum 83 (NAD 83) geographic coordinates to NAD 83 Oregon State plane coordinates – north zone. HYPACK, acting as a data manager, displayed the vessel's position relative to a proposed sampling location in plane view on a video screen. The resultant pictorial screen presentation, as well as numeric navigation data, assisted the vessel operator in approaching and maintaining the proposed sampling location while sampling. Once the sampling device impacted the bottom the actual sampled position was recorded in a file on the computer by hitting an event mark."

6.0 Current Study

6.1 Columbia River Data

As mentioned earlier in this study, eighty-nine stations (no sample was recovered after 4 tries at #45) were sampled from the Columbia River Channel, river mile (RM) 6.00 to RM 106.20, 90 samples were submitted for physical analysis, of which, 23 were further analyzed for chemical contaminants. This data is presented below:

Physical, Total Organic Carbon (TOC) & Total Volatile Solids (TVS) Analysis: Results for physical, TOC and TVS analysis are presented in Table 5. As expected, 95% of the material recovered was classified as poorly graded sand with a mean grain size of 0.56 mm and an average TVS of 0.62%. Of the 90 samples submitted for physical analysis only 4 (#s 07,57,75A, 76) exceeded 20% fines and had greater than 5% TVS. These samples, excluding #75A, were submitted along with 20 other samples for chemical analysis. Sample #75A represents a portion of sample CR-BC-75. (For more information on sample #75A see section 7.0 "Discussion").

Metals: Results for metals are presented in Table 6. Twenty-three sediment samples were analyzed for 9 metals, As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, and Zn. Of the 23 samples submitted 3 samples (#s 07,57,76) showed the highest levels of metals, but none of the levels approached the screening level (SL).

Pesticides and PCBs: Results for Pesticides and PCBs are presented in Table 7. Pesticides were found in 4 of 23 samples (#s.07,57,74,76) tested. The laboratory flagged all of these values with a "J" notation, which indicates the values are considered estimate concentrations. They are considered estimates because the value is less than the method reporting limit (MRL), but greater than the method detection limit (MDL). PCBs were found in sample #76 only. None of the pesticides or PCB levels that were found in samples exceeded the SL for total PCBs.

Polynuclear Aromatic Hydrocarbons (PAHs): Results for PAHs are presented in Table 8&9. Low levels of PAHs were found in most of the 23 samples submitted for chemical analysis. Three samples (#s 07,57,76) showed the largest individual amounts of both high and low density PAHs detected. All levels detected as well as totals, of low and high density PAHs were well below the SLs.

P450 Reporter Gene Assay, (Dioxin/Furan Screen). Results for P450 RGA are presented in (Table 10): P450 is the designation for a group of enzymes that play a key role in activating or deactivating many toxic chemicals including PAHs, PCBs, dioxins and furans. Sample CR-BC-76 is the only sample, taken from the Columbia River, that is a candidate to contain dioxins/furans. If the area associated with CR-BC-76 were to be dredged in the future, it would warrant further testing for dioxin/furans. (Dioxin/furan contaminates were found in a select set of fine grained material sampled outside of the navigational channel, see 1991 & 1993 Bi-State Reconnaissance survey.)

6.2 Willamette River Data

As mentioned earlier, for this study, sixty-eight sediment samples (includes replicates and multiple samples from some cores) were collected in June 1999 from 43 sites on the Willamette River, from RM 0.10 to RM 11.55. This data is presented below:

Physical, Total Organic Carbon (TOC) & Total Volatile Solids (TVS) Analyses: Results for physical, TOC and TVS analyses are presented in Table 11. Of the 68 samples analyzed for grain size, 43 (63%) exceeded 20% fines and/or 5% volatile solids. The distribution of fines varied within the sampled area, both up and down the river as well as from the surface to the depth of the cores sampled.

Metals: Results for metals analyses are presented in Table 12. Fifty-two sediment samples were analyzed for 9 inorganic metals (As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, & Zn) and for organotin (TBT)(pore water). Of the 52 samples analyzed only the following exceeded SLs for metals, #42C for mercury and #42D for lead. Tributyltin exceeded the SL in samples #23 and #21.

Pesticides and PCBs: Results for pesticides and PCBs analyses are presented in Table 13. Of the 52 samples submitted, the SL was exceeded for DDT in nine samples (#s 4A, 4B, 21, 24A, 25A, 29, WR-C, 35A, 40A). Only one other pesticide, Dieldrin, exceeded the SL, sample (#40A). PCBs exceeded SL in only one sample, #42C.

Polynuclear Aromatic Hydrocarbons (PAHs): Results for PAHs are presented in Table 14 & 15. Sample #s 20 and 22 exceeded almost all of the SLs and totals for both low and high PAHs. Sample #21, 11A & 15 exceeded SL for 2 PAHs. Sample # 16 exceeded one SL for PAHs. Sample #s 11 through 22 are from RM 2.90 to RM 6.20. The heaviest concentration of these contaminates are from RM 5.15 to RM 6.20.

P450 Reporter Gene Assay, (Dioxin/Furan Screen): Results for P450 RGA are presented in Table 16. P450 is the designation for a group of enzymes that play a key role in activating or deactivating many toxic chemicals including PAHs, PCBs, dioxins and furans. Samples WR-GC-18A, 22, 24A, 30A, 32A, 33A, 38A are all candidates to contain dioxins/furans and therefore require specific attention. Four of the samples (18A, 24A, 30A, & 33A) contain similar amounts of PCBs; this accounts for the chlorinated hydrocarbons detected in the P450 RGA. Three samples (22, 32A, 38A) contain possible low levels of dioxin/furans. Sample WR-BC-22 contains possible higher levels of dioxin/furan. If the area represented by these samples were to be dredged, it would warrant further testing for dioxin/furans.

In September 1999 additional surface sediment samples were collected from 12 deep-water sites in the Willamette River (see Exhibit B, table 4, for station coordinates and water depths). All samples were collected below the proposed 43-foot (plus 2-foot overdepth) deepening project and ranged from –48 feet to –79 feet below the Columbia River Datum (CRD). Various stations exceeded the screening levels and maximum levels of the DMEF for several organic contaminate (see tables 18 –21). No sample exceeded SL's for metals or TBT (see table 17). As with the CRCD shoal samples and the EPA-DEQ 1997-1998 Sediment Quality Study, the middle reach of the river (RM 4.0to 8.0) is the most contaminated. High levels of PAHs were found at RM 6.1 (Grab-05).

7.0 Discussion

7.1 Samples of Interest – Columbia River

Sampling on the Columbia River was done using a Van Veen grab sampler. This type of sampler was selected because the nature of the material sampled is primarily a coarse grained sand with few volatile solids, which does not core well. Because of the types of shoaling and constant reworking of the material proposed to be dredged it is homogenous in nature. A surface grab sample, therefore, is representative of the shoal to be dredged. This study confirms and supports the "Exclusionary" ranking given to the majority of the mainstem of the Columbia River Federal Navigation Channel.

Sample station CR-BC-75 was the deepest station of a series of three sampling stations at RM 99+20. These stations are located just downstream of the mouth of the Willamette River and the Morgan Bar disposal area, which receives fine-grained material, dredged from the

Willamette River. For the reasons stated, these stations were selected for physical and chemical analyses as part of the CRCD Feasibility study sampling and analysis plan (see attached). After collecting a sample at station CR-BC-75 for chemical analysis, a 3-4" layer of "clay" was noted below the top of the sampler. As this sample had been touched and therefore could not meet sampling protocols for chemical analyses, only a sample for physical analyses was collected. This sample was labeled CR-BC-75A. The NMFS's boat had moved off the station to the next sample location, CR-BC-76, so station CR-BC-75 was not resampled. At the time of sampling at station CR-BC-75 the water depth was recorded to be 71 feet. Correcting for river stage, depth of the sounding transducer, and Columbia River Datum (CRD) the water depth below CRD would be approximately 59.5 feet at this location. This is 14.5 feet below present dredging depths and 11.5 feet below a proposed 48-foot channel (43ft + 5 ft advance O&M). The fine-grained material represented by CR-BC-75A is well below any existing or proposed dredging prism.

<u>Station CR-BC-76</u> This sample was not scheduled to be chemically analyzed, but when the field personnel saw that it was fine-grained material, a chemical sample was added. Sample CR-BC-76 contained the highest levels of most chemicals of concern, but these levels were still well below SLs.

<u>Station CR-BC-45</u> No sample was submitted for analysis from this station. After 4 unsuccessful attempts to recover sediment without success, no further attempts were made to sample this station.

<u>Station CR-BC-07 & 57</u> These two sample were of interest only because they contained higher levels of contaminates (along with # 76) than other samples taken from the Columbia River, in this study. While they contained the highest levels of contaminates in the Columbia River, they are still considered low levels, well below the Tier II SLs. Sample CR-BC-07 represents material from the turning basin in Astoria. Sample CR-BC-57 is outside the Columbia River Federal Navigation Channel in shallow water not in an area proposed to be dredged.

7.2 Samples of Interest - Willamette River

Willamette River Channel sediments are fined grained and more heterogeneous in nature than the Columbia River Channel sediments. A 4" vibra core sampler was used for collecting samples to various depths; samples designated "GC" and the "CD". The samples, surface to 10" deep, were taken with a Van Veen box corer and numbered sequentially using WR-BC-## convention.

<u>Station WR-GC-22</u> This sample was taken at river mile 6.2 on the Willamette River. It had a physical composition of only 4.4 % finer than sand with volatile solids of 2.3 %. The content of total low density PAHs was 395,500 ppb, which is 76 times the current SL and 13.6 times the maximum level (ML) the bioaccumulation trigger. The content of total high density PAHs was 1,024,100 ppb, which is 85 times the current SL and 14.8 times the ML. A possible explanation for this coarse grained material holding this unusually high level of contamination could be that this material is "native" sediment which has not moved since being contaminated, either by dredging or natural scouring by river currents.

Station WR-GC-24 Sample 24 was taken at river mile 6.7 on the Willamette River. This 7.1-foot long core sample was divided into 3 composite samples. The surface to 5.5-foot depth was labeled "A", the section from 5.5 feet to 6.4 feet labeled "B", and the 6.4 feet to 7.1 feet labeled "Z" (physical analysis only). The "A" sample physical analysis showed a composition of 84.5% finer than sand while the "B" sample showed 46.0% finer than sand and "Z" only 9.5 % finer than sand. Chemically the "A" sample contained higher levels of all chemicals of concern; most notable was total DDT. Sample "A" contained 198-ppb total DDT (SL 6.9-ppb) while sample "B" contained only 2.2-ppb total DDT.

Station WR-GC-42 This sample was an 18-foot core sample that was divided into 4 composite samples. Surface to 5.4 feet was labeled "A", 5.4 feet to 10.8 feet "B", 10.8 feet to 16.2 feet "C", and 16.2 feet to 18.0 feet "D". The "D" sample exceeded the SL (130-ppb) for PCBs, with an analysis of 246.0-ppb PCBs. The other composites were < 57-ppb PCBs.

Station WR-GC-43 Sample 43 was a 12.9 foot core sample that was divided into 3 composite samples (surface to 0.5 feet was wood chips lost during coring). Sample "A" was from 0.5 to 5.4 feet, sample "B" 5.4 feet to 10.7 feet and sample "Z" (physical analysis only) from 10.7 feet to 16.2 feet. The "A" sample contained 489.0-ppb lead, while its blind replicate WR-D contained 64.3-ppb and the "B" sample only 15.0-ppb. The "A" sample may have contained an isolated piece of lead.

These and other sites, which exceed the SL for contaminates of concern, would require careful further consideration if dredging and disposal were to take place.

7.3 Composite Samples, Field Replicates and Laboratory Quality Control

The Columbia River samples CR-BC-11/12 and CR-BC-66/67 were composite samples. Sample CR-BC- 75A was fine-grained material taken out of the same grab sample as CR-BC-75 (see Discussion, Columbia River Samples of Interest, above).

On the Willamette River samples WR-BC-12/13/14, WR-BC-16/17 and WR-BC-26/27/28 were composite samples. The following primary samples are matched with their blind replicate sample: WR-BC-01 & WR-A, WR-BC-10 & WR-B, WR-BC-29 & WR-C, WR-BC-43 & WR-D. Blind replicate samples were used as a laboratory quality check. The correlation of data between the primary and three replicates, WR-A, WR-B, WR-C (except P-450 on WR-C) was good. Sample WR-D did show good correlation on the physical analysis, pesticides/PCBs and P-450, but showed poor correlation with the primary sample on TOC, metals, and PAHs. Other laboratory controls used were surrogate samples, laboratory duplicates, matrix spike/matrix spike duplicate samples, laboratory control samples and method blanks. The percent recovery and relative percent differences were within acceptable limits, with few exceptions. The laboratory confirmed samples outside the laboratory control limits with a second confirming analysis.

7.4 Sample Location Maps

As previously mentioned sample location selection was based on the following:
Station locations on the Columbia River were chosen from shoal areas as indicated on the most recent Channel Condition Surveys performed by the USACE, Portland District Hydrographic Survey Branch (Table 3). Station locations on the Willamette River were selected by Tom Rosetta of the Department of Environmental Quality (DEQ), Rick Vinning of Department of Ecology (DOE), and John Malek of the Environmental Protection Agency (EPA), Region 10 based upon shoals identified in the 1994 channel condition survey and proposed channel alignment. The sample location maps (Plates 1 –27) attached to this report show the actual sampling station location (see section 2.0 of this report for discussion of actual versus proposed location).

7.5 Radionuclides

As with all sediment quality evaluations a sequential approach called a tiered evaluation process was used to determine if there is a reason-to-believe radionuclides pose an unacceptable adverse effect to the environment or human health if dredged. This includes placement. The present evaluation approach involves tiers designed and used in a sequential manner for evaluating the suitability of dredged material for unconfined aquatic disposal. Material found suitable for open-water disposal is usually considered also suitable for upland disposal. At each tier a decision is made regarding the adequacy of the existing data to make a suitability determination. If the existing data is adequate for decision purposes, then there is no need to proceed to the next tier.

Tier I consists of compiling and evaluating existing information on specific dredging sites; determine if exclusion-from-testing or recency/frequency guidelines apply; and determine if there exists a reason-to-believe that significant contamination is present. The Lower Columbia River Bi-State program, conducted in 1993 by Tetra Tech, reported that "Radionuclides have probably been the most extensively studied contaminate in the Columbia River." Radionuclides occur naturally in the earth's crust and they also occur as a result of human activity. Significant sources of radionuclides to the Columbia River include historical and present releases from the Hanford plutonium production facility, fallout from historical above-ground nuclear weapons testing, and radionuclides fallout from the April 1986 Chernobyl nuclear power plant accident. The Trojan Nuclear Power Plant was not a significant source of radionuclides to the river based upon environmental monitoring.

For more than 40 years the U.S. Government produced plutonium for nuclear weapons at the Hanford Site in south central Washington State. During that time, Hanford released radioactive elements and other materials into the Columbia River. Columbia River water was used to cool up to 8 plutonium production reactors. The first three were built during World War II and five more were added between 1949 and 1955. The first reactor began operation in September 1944 and the last was shut down in January 1971. As various elements and chemicals passed through the reactor's cores with the cooling water they became radioactive. After leaving the cores, the cooling water went into retention basins then was discharged into the Columbia River.

Because of the construction of the 5 additional reactors and increased production levels of all the reactors increasing amounts of radioactivity was discharged to the Columbia River. The radioactive contamination levels in the Columbia River were highest from 1957 to 1964. Additional releases resulted from fuel element failure and flushing, reactor purging, of the cooling tubes.

There were two other factors that influenced the passage of radionuclides in the river; seasonal changes and the construction of dams. Summer and fall were likely peaks in exposure levels in river areas near Hanford due to low flows and warmer water. Dams slowed the flow of the river allowing more radioactive materials to adhere to the sediment trapped behind the dams. The radioactive materials were further decreased by decay before reaching the down river area.

According to the Technical Steering Panel of the Hanford Environmental Dose Reconstruction Project (TSP, 1994), there were five radionuclides that contributed 94 percent of the radiation exposure. The five were phosphorus-32, zinc-65, arsenic-76, neptunium-239 and sodium-24. There were many other radioactive materials released into the river, but they contributed much less radiation.

The USGS in cooperation with the US Atomic Energy Commission published a series of Geological Survey Professional Papers between 1973 and 1975 on Columbia River radionuclide contamination (USGS, 1973-1975). Field work began in 1962 and lasted through 1966. The purpose of the investigations was to determine the decay, distribution, and movement of radionuclides in the Columbia River. As part of the investigation, surveys were made of the distribution of radionuclides and sediments in the streambed between the reactors and The Dallas Dam in September 1965; between The Dallas and Bonneville Dams in October and November 1964; and between Bonneville Dam and Longview, Washington in April 1965. In addition, radionuclide concentrations and particle-size distributions of surficial sediment were observed for samples collected semimonthly during 1963, and intermittently at other times during 1962-1965, from the streambed at Pasco and Vancouver, Washington and Hood River, Oregon.

To provide information on the distribution of radionuclides in the estuary (Longview to the mouth of the Columbia River), the physical and radiological character of the streambed was investigated in 1965. Gross gamma radiation was measured in situ, and surficial samples and cores were obtained at 14 cross sections. These analyses correspond to the timeframe of maximum radionuclide discharge from Hanford, 1957-1964.

In the proposed project area (Portland, Oregon to the mouth of the Columbia River) the most abundant radionuclides measured were Cr^{51}, Zn^{65}, Sc^{46}, Ru^{106}, Mn^{54}, Co^{60}, and Zr^{95}- Nb^{95} which were approximately 6.2, 2.2, 0.2, 0.1, 0.07, 0.06, and 0.05 times, respectively, the concentration of naturally occurring K^{40}. The stratigraphic distribution of radionuclides was also found to vary considerably. Radionuclides tended to be distributed to the greatest depths in channels and on slopes and may extend more than 60 inches below the bed surface. However, on the average, 66 percent of the total amount of measured radionuclides (excluding K^{40}) was concentrated in the upper 8 inches of the streambed. While radionuclide concentrations varied greatly, generally the lowest were in channels and the highest were on slopes and flats.

Sediment texture influences the radionuclide content significantly. Radionuclide concentrations increased as the mean size of sediment decreased, as sediment became less well sorted, and as the skewness of the sediment size distribution changed from negative to positive. Main channel sediments are sands low in fines and organic content (see Table 5)

Over 60 different radionuclides have been reported in effluent from the Hanford reactors. At least six of these were discharged at relatively high concentrations and are relatively long-lived Cr^{51} (half-life 27.8 days), Zn^{65} (245 days), Sc^{46} (84 days), Mn^{54} (314 days), Co^{60} (5.3 years), and Sb^{124} (60 days). Radionuclides with longer half-lives were discharged in relatively low quantities [e.g., Pu^{239} (24,000 years), and Cs^{137} (30.2 years)]. Those radionuclides with half-lives shorter than 2.5 years that were released to the river prior to 1972 would be effectively gone.

The Oregon Hanford Waste Board feels that levels have dropped to well within health and safety standards, although traces of radioactive elements from Hanford can still be found in the river sediments today. The Washington Department of Health (WDH) in a March 1994, Special Report titled "Radioactivity in the Columbia River Sediment and Their Health Effects" (WDH, 1994) reviewed and presents an excellent summary of existing data provided by state agencies, federal agencies, and academic researchers. These data span the length of the river and the coastlines of Oregon and Washington. The WDH concludes that these data are sufficient to establish human health risks. Although traces of radioactive materials remain in the river, monitoring by the states of Oregon and Washington and others indicate that radionuclides do not currently pose a health hazard.

The short lived radionuclides are essentially gone and the artificial intermediate and long-lived radionuclides are at or near the lower limit of detection, regardless of sampling location. The 1994 WDH report in its Executive Summary found that:

> "The maximum radiation doses from surface sediments come from the Hanford Reach of the river. In general, the calculated dose, like the measured concentrations of artificial radioactivity, decline rapidly with distance from Hanford. In all cases the calculated doses are low and less than 1% of natural background. In fact, the risk from these doses are less than the risk associated with existing federal standards for radionuclides in drinking water and air emissions."

Based upon a Tier I review of existing information it was determined that there was not a reason-to-believe that dredging of the Columbia River Navigation Channel by an additional 3 feet would poses an unacceptable risk to the environment or human health due to radionuclides present in the sediment. No further testing at higher tiers is necessary.

8.0 Conclusions

The proposed material to be dredged from the mainstem of the Columbia River consists of clean sands low in fines and organic content. The areas identified consist of sand wave or cut line shoals formed by bedload transport. Material distribution in these shoals is homogeneous due to source and consistency of the hydraulic regime, which form the shoals.

The current sampling event data (Tables 5-10) confirms the "Exclusionary" ranking for the material in the Columbia River federal navigational channel. It also shows that the area from RM 74 to 88 and RM 99 to 106, that was previously ranked "low" due to lack of data, now fit the "exclusionary" ranking, also. Therefore, all samples taken inside the purposed federal channel in the Columbia River upheld the "exclusionary" ranking and would require no further testing before disposal under the guidelines of the DMEF and could be disposed of under either the CWA section 404 or the Marine Protection, Research and Sanctuaries Act (MPRSA) section 10.

Sediment testing is conducted in accordance with the laws, regulations, and guidance as discussed in previous comments. Coarse grained sediments are not subjected to chemical and higher tier testing unless there is a reason to believe the sediments could be contaminated with a chemical of concern. A primary factor in this determination is proximity to contamination sources. The need to chemically test Columbia River sediment samples, though not required, was conducted as part of this study. All data, both historical and current, was used in evaluating potential environmental impacts of dredged material management alternatives to meet the substantive and procedural requirements of the National Environmental Policy Act, The Clean Water Act and the Marine Protection, Research and Sanctuaries Act. This evaluation would make all material represented by this sampling event on the Columbia River suitable for unconfined aquatic disposal.

For the Willamette River portion of the project, all sediments regardless of physical properties were subjected to chemical testing. Of the 68 samples analyzed from the 43 sampling stations, 13 samples exceeded the SL for 1 or more contaminates. The material represented by these samples would not be suitable for unconfined aquatic disposal under Tier II testing SLs. These areas, if dredged, would be required to either under go biological testing under Tier III or be disposed of under guidelines and regulations for confined in-water or upland. Sampling and analyses of deep-water sites (12 locations, Grab-1 through 12) in the Willamette River show surface sediment to be contaminated with DDT and PAHs above the DMEF screening levels in several locations. These areas should be evaluated further for possible locations for dredged material disposal.

The local sponsors for the CRCD project have requested that the Willamette River dredging be delayed. If the harbor is listed as a "Super Fund" site no navigational maintenance or new work dredging can be conducted in the listed area under the CWA. If the harbor is not listed dredging for navigation channel deepening would not preclude cleanup activities but would enhance and perhaps extend the effort. The dredging in the Willamette River would require full compliance with the all laws including the CWA, ESA, and NEPA.

Table 1, CRCD Sediment Evaluation Report

Columbia River Channel Deepening
Proposed Sediment Sampling Locations

Sample	Longitude	Latitude	RM	Remarks
CR-BC-1	-123:59:03.3343	46:14:01.9406	6+00	Desdemona Shoal
CR-BC-2	-123:58:40.4168	46:13:53.8876	6+18	Desdemona Shoal
CR-BC-3	-123:58:21.3699	46:13:35.9257	6+40	Off Buoy 22
CR-BC-4	-123:56:00.2036	46:12:12.4797	9+10	Flavel Bar (Chem)
CR-BC-5	-123:54:10.8466	46:11:24.0717	11+00	Flavel Bar
CR-BC-6	-123:53:15.0373	46:11:30.4439	11+40	Flavel Bar
CR-BC-7	-123:52:13.3125	46:11:32.2848	12+30	Flavel Bar
CR-BC-8	-123:51:51.6669	46:11:24.7337	12+45	Flavel Bar (Chem)
CR-BC-9	-123:49:11.7802	46:11:49.6890	15+00	Upper Sands
CR-BC-10	-123:47:34.3607	46:12:26.5769	16+25	Upper Sands
CR-BC-11	-123:45:06.0607	46:13:18.6687	18+35	Tongue Pt. X-ing
CR-BC-12	-123:43:34.5881	46:13:49.2555	20+00	Tongue Pt. X-ing
CR-BC-13	-123:48:56.1150	46:17:08.7026	20+50	Tongue Pt. X-ing
CR-BC-14	-123:41:32.6230	46:14:51.4486	22+00	Tongue Pt. X-ing
CR-BC-15	-123:39:27.5695	46:15:23.5588	23+40	Miller Sands (L side)
CR-BC-16	-123:38:17.4846	46:15:35.0619	24+40	Miller Sands
CR-BC-17	-123:35:14.5464	46:15:22.4087	27+10	Pillar Rock
CR-BC-18	-123:33:31.3486	46:15:26.9171	28+30	Pillar Rock
CR-BC-19	-123:32:02.0550	46:15:40.1670	29+40	Pillar Rock
CR-BC-20	-123:29:16.2230	46:16:18.7428	32+05	Brooksfiel-Welch (L side)
CR-BC-21	-123:27:58.5393	46:16:05.1881	33+10	Skamokawa Bar (L side)
CR-BC-22	-123:26:17.2022	46:14:49.5667	33+10	ditto (L of Ctr., Chem)
CR-BC-23	-123:25:29.3459	46:12:33.2189	38+00	Puget Is. Bar
CR-BC-24	-123:25:38.0984	46:11:41.0153	39+00	Puget Is. Bar (R side, Chem)
CR-BC-25	-123:24:58.0377	46:10:15.4260	40+45	Wanna-Driscoll(L Ctr,Chem)
CR-BC-26	-123:23:14.5903	46:09:02.2613	42+40	ditto (L of Ctr., Chem)
CR-BC-27	-123:21:36.4559	46:08:41.7907	44+10	Wanna-Driscoll
CR-BC-28	-123:20:36.9378	46:08:32.5597	45+00	Wanna-Driscoll
CR-BC-29	-123:19:21.2834	46:08:32.0508	46+00	West Port Bar
CR-BC-30	-123:17:51.5459	46:08:37.8018	47+10	West port Bar
CR-BC-31	-123:16:52.1139	46:08:48.6908	48+00	West port Bar
CR-BC-32	-123:13:12.8288	46:10:14.6658	51+20	West port Bar
CR-BC-33	-123:09:35.6055	46:11:20.3455	54+30	Island Bar (L side)
CR-BC-34	-123:07:17.7356	46:11:07.9353	56+20	Stella-Fisher Bar (L side)
CR-BC-35	-123:06:15.6285	46:10:43.4611	57+20	ditto (R side, Chem)
CR-BC-36	-123:05:18.2519	46:10:09.7332	58+20	Stella-Fisher Bar
CR-BC-37	-123:11:29.7216	46:13:28.9081	59+10	Stella-Fisher Bar
CR-BC-38	-123:03:10.7658	46:09:15.3678	60+20	Walker Is. (L side)
CR-BC-39	-123:01:30.0908	46:08:26.9657	62+00	Walker Is.
CR-BC-40	-123:00:12.3010	46:07:58.3243	63+10	Slaughters Bar (Chem)
CR-BC-41	-122:59:29.9738	46:07:27.0209	64+00	Slaughters Bar Chem)
CR-BC-42	-122:58:38.1992	46:06:48.7298	65+00	Slaughters Bar
CR-BC-43	-122:57:52.6910	46:06:25.0230	65+40	Slaughters Bar
CR-BC-44	-122:57:20.4945	46:06:19.3331	66+10	R Turning Basin Lower
CR-BC-45	-122:56:30.9667	46:06:01.3646	66+50	R Turning Basin Upper

Table 1, CRCD Sediment Evaluation Report

Columbia River Channel Deepening
Proposed Sediment Sampling Locations

CR-BC-46	-122:56:09.8545	46:05:50.3446	67+15	L Dobelbower Bar (R side)
CR-BC-47	-122:53:00.0084	46:03:51.2050	70+45	U Dobelbower Bar
CR-BC-48	-122:52:46.5037	46:03:01.3898	71+45	U Dobelbower Bar
CR-BC-49	-122:52:17.2524	46:01:43.0832	73+25	U Dobelbower Bar (R side)
CR-BC-50	-122:51:07.9427	46:00:43.8057	74+50	Kalama (R of Ctr.)
CR-BC-51	-122:50:47.3695	45:59:53.3304	75+50	Kalama (R of Ctr.)
CR-BC-52	-122:50:21.3255	45:59:04.7564	76+50	@E8 on BiState (Chem)
CR-BC-53	-122:48:36.9406	45:57:26.6275	79+20	L Martin Is. Bar (L side)
CR-BC-54	-122:48:17.0262	45:56:23.2216	80+35	U Martin Is. Bar (L side)
CR-BC-55	-122:48:25.1414	45:55:07.9420	82+08	U Martin Is. Bar (Chem)
CR-BC-56	-122:48:25.0157	45:54:23.5578	83+00	U Martin Is. Bar (Chem)
CR-BC-57	-122:48:82.-----	45:54:32.------	83+34	@E9D on BiState (Chem)
CR-BC-58	-122:47:54.8348	45:53:04.4499	84+31	Jct w/ St. Helens Ch (Chem)
CR-BC-59	-122:47:25.0667	45:52:29.2106	85+20	St Helens Bar (L side, Chem)
CR-BC-60	-122:47:10.1016	45:52:07.1731	85+45	St Helens Bar (L side)
CR-BC-61	-122:47:04.2865	45:51:21.7615	86+40	ditto (L sideslope, Chem)
CR-BC-62	-122:47:15.7772	45:50:19.6795	88+00	Warrior Rock Bar
CR-BC-63	-122:47:35.6691	45:49:30.0103	89+00	Warrior Rock Bar (R side)
CR-BC-64	-122:47:33.9660	45:48:40.4233	90+00	Henrici Bar (R side)
CR-BC-65	-122:47:05.5824	45:47:53.7864	91+00	Henrici Bar
CR-BC-66	-122:46:28.2783	45:47:08.5875	92+00	Henrici Bar (L of Ctr.)
CR-BC-67	-122:45:51.3934	45:46:25.2233	93+00	Henrici Bar
CR-BC-68	-122:45:34.4431	45:45:36.7177	93+50	Henrici Bar (R of Ctr.)
CR-BC-69	-122:45:33.6004	45:44:42.5466	95+00	Henrici Bar
CR-BC-70	-122:45:36.7032	45:43:51.4174	96+00	Henrici Bar
CR-BC-71	-122:45:54.2874	45:43:00.7651	97+00	Willow Bar
CR-BC-72	-122:46:11.6581	45:42:10.0429	98+00	Willow Bar
CR-BC-73	-122:46:20.5107	45:41:00.6805	99+20	Morgan Bar (R of Ctr, Chem)
CR-BC-74	-122:46:27.7855	45:41:00.0435	99+20	Morgan Bar (Ctr. Ch, Chem)
CR-BC-75	-122:46:31.9109	45:40:59.6139	99+20	Morgan Bar (L side, Chem)
CR-BC-76	-122:46:07.9882	45:40:09.1738	100+20	Morgan Bar (R of Ctr)
CR-BC-77	-122:46:03.8366	45:39:47.0415	100+45	Morgan Bar (L side)
CR-BC-78	-122:45:35.0403	45:39:22.6433	101+25	Morgan Bar (R side)
CR-BC-79	-122:44:39.0406	45:38:50.7520	102+25	L Vancouver (R side)
CR-BC-80	-122:43:45.1358	45:38:37.8835	103+12	L Vancouver (R side, Chem)
CR-BC-81	-122:43:03.0185	45:38:27.3920	103+45	L Vancouver (R side)
CR-BC-82	-122:43:04.5671	45:38:25.2145	103+45	L Vancouver (Ctr. Channel)
CR-BC-83	-122:43:05.7394	45:38:23.1613	103+45	L Vancouver (L side)
CR-BC-84	-122:42:40.6247	45:38:19.6836	104+10	U Vanc. (R/S, Chem. Cu spill)
CR-BC-85	-122:42:16.1175	45:38:09.6405	104+10	U Vanc. (R/S, Chem.Cu spill)
CR-BC-86	-122:41:24.1493	45:37:38.6678	105+25	Downsteram RR Brdg(Chem)
CR-BC-87	-122:41:07.3576	45:37:29.9672	105+40	Upstream RR Brdg
CR-BC-88	-122:40:28.6568	45:37:16.7597	106+20	D/S of I-205 Br. (R/C, Chem)
CR-BC-89	-122:40:32.7099	45:37:11.1850	106+20	Downstream of I-205 (L/C)

Table 2, CRCD Sediment Evaluation Report

Columbia River Channel Deepening
Actual Sediment Sampling Locations

Sample	Longitude	Latitude	RM	Remarks
CR-BC-1	-123:59:08.3	46:14:00.7	6+00	Desdemona Shoal
CR-BC-2	-123:58:41.1	46:13:54.6	6+18	Desdemona Shoal
CR-BC-3	-123:58:22.4	46:13:36.6	6+40	Off Buoy 22
CR-BC-4	-123:56:09.1	46:12:11.0	9+10	Flavel Bar (Chem)
CR-BC-5	-123:54:09.1	46:11:24.0	11+00	Flavel Bar
CR-BC-6	-123:53:03.3	46:11:30.5	11+40	Flavel Bar
CR-BC-7	-123:52:13.1	46:11:32.2	12+45	Flavel Bar (Chem)
CR-BC-8	-123:52:40.4	46:11:51.8	12+30	Flavel Bar
CR-BC-9	-123:49:27.2	46:11:80.0	15+00	Upper Sands
CR-BC-10	-123:47:33.6	46:12:22.8	16+25	Upper Sands
CR-BC-11	-123:45:06.4	46:13:18.5	18+35	Tongue Pt. X-ing
CR-BC-12	-123:43:82.1	46:13:74.0	20+00	Tongue Pt. X-ing
CR-BC-13	-123:42:79.8	46:14:23.7	20+50	Tongue Pt. X-ing
CR-BC-14	-123:41:79.0	46:14:74.8	22+00	Tongue Pt. X-ing
CR-BC-15	-123:39:32.9	46:15:44.5	23+40	Miller Sands (L side)
CR-BC-16	-123:38:25.9	46:15:57.9	24+40	Miller Sands
CR-BC-17	-123:35:24.2	46:15:35.2	27+10	Pillar Rock
CR-BC-18	-123:33:61.0	46:15:43.1	28+30	Pillar Rock
CR-BC-19	-123:32:02.3	46:15:64.3	29+40	Pillar Rock
CR-BC-20	-123:29:16.0	46:16:27.5	32+05	Brooksfield-Welch (L side)
CR-BC-21	-123:27:58.4	46:16:05.1	33+10	Skamokawa Bar (L side)
CR-BC-22	-123:26:17.4	46:14:85.9	33+10	ditto (L of Ctr., (Chem)
CR-BC-23	-123:25:72.2	46:12:60.0	38+00	Puget Is. Bar
CR-BC-24	-123:25:72.2	46:11:50.0	39+00	Puget Is. Bar (R side, (Chem)
CR-BC-25	-123:25:26.3	46:10:33.9	40+45	Wanna-Driscoll(L Ctr, (Chem)
CR-BC-26	-123:23:36.0	46:09:06.5	42+40	ditto (L of Ctr., (Chem)
CR-BC-27	-123:21:64.0	46:08:68.7	44+10	Wanna-Driscoll
CR-BC-28	-123:20:68.4	46:08:53.7	45+00	Wanna-Driscoll
CR-BC-29	-123:19:50.5	46:08:52.8	46+00	West Port Bar
CR-BC-30	-123:19:50.5	46:08:69.2	47+10	West port Bar
CR-BC-31	-123:16:49.8	46:08:88.6	48+00	West port Bar
CR-BC-32	-123:13:30.0	46:10:24.4	51+20	West port Bar
CR-BC-33	-123:09:77.7	46:11:33.5	54+30	Island Bar (L side)
CR-BC-34	-123:07:60.4	46:11:14.0	56+20	Stella-Fisher Bar (L side)
CR-BC-35	-123:07:47.5	46:10:76.1	57+20	ditto (R side, (Chem)
CR-BC-36	-123:05:35.9	46:10:12.9	58+20	Stella-Fisher Bar
CR-BC-37	-123:04:59.5	46:09:71.7	59+10	Stella-Fisher Bar
CR-BC-38	-123:03:46.8	46:09:29.0	60+20	Walker Is. (L side)
CR-BC-39	-123:01:85.0	46:08:52.4	62+00	Walker Is.
CR-BC-40	-123:00:36.9	46:07:99.3	63+10	Slaughters Bar (Chem)
CR-BC-41	-122:59:59.2	46:07:41.0	64+00	Slaughters Bar (Chem)
CR-BC-42	-122:58:76.7	46:06:70.7	65+00	Slaughters Bar
CR-BC-43	-122:58:02.9	46:06:41.0	65+40	Slaughters Bar
CR-BC-44	-122:57:47.0	46:06:36.4	66+10	R Turning Basin Lower
CR-BC-45	no sample – 3 attempts		66+50	R Turning Basin Upper

Table 2, CRCD Sediment Evaluation Report

Columbia River Channel Deepening
Actual Sediment Sampling Locations

CR-BC-46	-122:56:17.8	46:05:79.2	67+15	L Dobelbower Bar (R side)
CR-BC-47	-122:53:10.4	46:03:83.6	70+45	U Dobelbower Bar
CR-BC-48	-122:52:86.5	46:03:11.3	71+45	U Dobelbower Bar
CR-BC-49	-122:52:41.3	46:01:81.0	73+25	U Dobelbower Bar (R side)
CR-BC-50	-122:51:15.4	46:00:74.9	74+50	Kalama (R of Ctr.)
CR-BC-51	-122:50:32.4	45:59:81.6	75+50	Kalama (R of Ctr.)
CR-BC-52	-122:50:42.5	45:59:03.7	76+50	@E8 on BiState (Chem)
CR-BC-53	-122:48:71.7	45:57:48.3	79+20	L Martin Is. Bar (L side)
CR-BC-54	-122:48:33.0	45:56:38.6	80+35	U Martin Is. Bar (L side)
CR-BC-55	-122:48:47.0	45:55:18.1	82+08	U Martin Is. Bar (Chem)
CR-BC-56	-122:48:52.0	45:54:36.2	83+00	U Martin Is. Bar (Chem)
CR-BC-57	-122:48:82.3	45:54:32.1	83+34	@E9D on BiState (Chem)
CR-BC-58	-122:47:91.8	45:53:00.1	84+31	Jct w/ St. Helens Ch (Chem)
CR-BC-59	-122:47:46.7	45:52:47.5	85+20	St Helens Bar (L side, (Chem)
CR-BC-60	-122:47:28.4	45:52:09.7	85+45	St Helens Bar (L side)
CR-BC-61	-122:47:20.0	45:51:48.2	86+40	ditto (L sideslope, (Chem)
CR-BC-62	-122:47:30.7	45:50:36.6	88+00	Warrior Rock Bar
CR-BC-63	-122:47:61.0	45:49:58.2	89+00	Warrior Rock Bar (R side)
CR-BC-64	-122:47:61.0	45:48:78.2	90+00	Henrici Bar (R side)
CR-BC-65	-122:47:28.4	45:48:00.7	91+00	Henrici Bar
CR-BC-66	-122:46:54.5	45:47:04.7	92+00	Henrici Bar (L of Ctr.)
CR-BC-67	-122:45:96.9	45:46:52.8	93+00	Henrici Bar
CR-BC-68	-122:45:70.9	45:45:66.7	93+50	Henrici Bar (R of Ctr.)
CR-BC-69	-123:45:67.7	45:44:73.7	95+00	Henrici Bar
CR-BC-70	-123:45:68.9	45:43:82.2	96+00	Henrici Bar
CR-BC-71	-123:46:00.0	45:42:97.4	97+00	Willow Bar
CR-BC-72	-123:46:27.8	45:42:14.0	98+00	Willow Bar
CR-BC-73	-123:46:41.3	45:40:99.3	99+20	Morgan Bar (R of Ctr, (Chem)
CR-BC-74	-123:46:54.5	45:40:99.6	99+20	Morgan Bar (Ctr. Ch, (Chem)
CR-BC-75	-123:46:61.7	45:41:00.0	99+20	Morgan Bar (L side, (Chem)
CR-BC-76	-123:46:21.0	45:40:13.0	100+20	Morgan Bar (R of Ctr)
CR-BC-77	-122:46:16.7	45:39:82.0	100+45	Morgan Bar (L side)
CR-BC-78	-122:45:62.7	45:39:31.9	101+25	Morgan Bar (R side)
CR-BC-79	-122:44:73.2	45:38:82.0	102+25	L Vancouver (R side)
CR-BC-80	-122:43:45.5	45:38:54.1	103+12	L Vancouver (R side, (Chem)
CR-BC-81	-122:43:10.1	45:38:43.8	103+45	L Vancouver (R side)
CR-BC-82	-122:43:17.5	45:38:42.2	103+45	L Vancouver (Ctr. Channel)
CR-BC-83	-122:43:17.4	45:38:36.5	103+45	L Vancouver (L side)
CR-BC-84	-122:42:74.4	45:38:30.1	104+10	U Vancouver (R side, (Chem) Copper spill)
CR-BC-85	-122:42:36.0	45:38:14.4	104+30	U Vancouver (R side, (Chem) Copper spill)
CR-BC-86	-122:41:53.0	45:37:66.1	105+25	Downstream RR Brdg (Chem)
CR-BC-87	-122:41:53.0	45:37:50.8	105+40	Upstream RR Brdg
CR-BC-88	-122:40:53.1	45:37:25.7	106+20	Downstrm of I-205 Brdg (R of Ctr., (Chem)
CR-BC-89	-122:40:54.1	45:37:19.5	106+20	Downstrm of I-205 (L of Ctr)

Table 3, CRCD Sediment Evaluation Report

Columbia River
Channel Condition Survey

Drawing #	Date	River Mile	Name
CL-28-211	17-Mar-97	28+40 to 32+35	Brooksfield-Welch Island Reach
CL-26-262	28-Apr-97	25+00 to 28+40	Pillar Rock Ranges
CL-21-285	15-Jan-97	21+20 to 25+20	Miller Sands Channel
CL-18-336	07-Oct-96	17+30 to 21+20	Tongue Point Crossing
CL-9-261	13-Nov-96	9+30 to 13+50	Flavel Bar
CL-14-207	07-Mar-97	13+30 to 17+30	Upper Sands
CL-4-96	06-Mar-97	2+30 to 6+25	Lower Desdemona Shoal
MC-1-680	09-Aug-96	-3+00 to 5+30	Entrance & Sand Island Ranges
CL-5-357	13-Nov-96	6+20 to 10+20	Upper Desdemona Shoal
CL-105-174	07-Jan-97	103+30 to 107+30	Vancouver Turning Basin
CL-102-259	06-Oct-96	100+40 to 104+50	Lower Vancouver Bar
CL-97-238	25-Sep-96	97+35 to 102+20	Morgan Bar
CL-94-255	16-Apr-97	93+40 to 97+45	Willow Bar
CL-44-243	11-Feb-97	44+20 to 48+20	Westport Bar
CL-40-261	13-Mar-97	40+20 to 44+30	Wauna & Driscoll Ranges
CL-36-235	13-Mar-97	36+30 to 40+50	Puget Island Bar
CL-33-244	17-Mar-97	32+30 to 36+40	Skamokawa Bar
CL-59-243	30-Apr-97	59+20 to 63+15	Walker Island Reach
CL-56-258	30-Apr-97	55+20 to 59+25	Stella-Fisher Bar
CL-54-192	01-May-97	51+40 to 55+45	Gull Island Bar
CL-50-211	12-Mar-97	47+55 to 51+50	Eureka Bar
CL-90-237	04-Mar-97	90+05 to 94+15	Henrici Bar
CL-87-201	04-Mar-97	86+30 to 90+40	Warrior Rock
CL-84-262	05-Mar-97	83+30 to 87+40	St. Helens Bar
CL-78-441	14-Jan-97	80+05 to 84+10	Upper Martin Island Bar
CL-78-436	22-Oct-96	76+20 to 80+25	Lower Martin Island Bar
CL-73-247	26-Mar-97	72+30 to 76+40	Kalama Ranges
CL-67-579	23-Jan-97	69+10 to 73+20	Upper Dobelbower Bar
CL-67-582	10-Mar-97	66+20 to 70+20	Lower Dobelbower Bar
CL-64-270	30-Apr-97	63+05 to 67+05	Slaughters Bar

Note: These survey maps were used to determine sediment sample locations representative of shoal areas.

Table 4, CRCD Sediment Evaluation Report

Columbia River Channel Deepening
Willamette River Sediment Sample Locations

Sample	Longitude	Latitude	RM	Remarks
WR-BC-1	-122:45:44.3362	45:39:13.3370	0.1	Rt. Mouth (Box Core)
WR-GC-2	-122:45:54.9805	45:39:16.5667	0.1	Lt. Mouth (Gravity Core)
WR-BC-3	-122:46:02.3906	45:39:02.1708	0.4	Lt.
WR-GC-4	-122:46:06.7203	45:38:43.8529	0.8	Lt. D/S Term 5 (-4 w/-5)
WR-GC-5	-122:46:08.0703	45:38:44.7709	0.8	Rt. D/S Term 5 (-4 w/-5)
WR-GC-6	-122:46:20.7350	45:38:42.8349	0.95	~ mid-channel
WR-BC-7	-122:46:57.3869	45:38:19.4082	1.6	~ mid-channel
WR-BC-8	-122:47:06.8303	45:38:12.1734	1.7	~ mid-channel
WR-BC-9	-122:47:16.6692	45:38:03.4129	2.05	~ mid-channel
WR-BC-10	-122:47:28.2057	45:37:41.3380	2.45	~ mid-channel
WR-GC-11	-122:47:26.2800	45:37:15.0665	2.9	~ mid-channel
WR-BC-12	-122:47:17.0763	45:36:57.6300	3.4	Rt. D/S Term 4; Composite
WR-BC-13	-122:47:11.6621	45:36:57.1153	3.4	Lt. Of C/L; Comp.-12,-14
WR-BC-14	-122:47:16.5328	45:36:52.2947	3.5	Lt. Of C/L; Comp.-12,-14
WR-BC-15	-122:47:14.0216	45:36:39.3717	3.8	Rt. Of C/L
WR-BC-16	-122:47:02.7247	45:36:23.8457	4.1	~C/L; Composite –16,-17
WR-BC-17	-122:46:58.8536	45:36:18.1072	4.4	~C/L; Composite –16,-17
WR-GC-18	-122:46:41.0228	45:36:11.5496	5.1	Rt. Of C/L
WR-GC-19	-122:46:17.4757	45:35:35.8326	5.1	Lt. Of C/L
WR-BC-20	-122:46:19.2367	45:35:30.2858	5.15	Rt. Of C/L
WR-BC-21	-122:45:45.1441	45:35:04.2830	5.9	Lt. D/S Moorings
WR-BC-22	-122:45:25.4092	45:34:53.8719	6.2	Lt. D/S Moorings
WR-BC-23	-122:45:08.0541	45:34:47.6289	6.5	~ mid-channel
WR-GC-24	-122:44:52.1496	45:34:38.5182	6.7	Rt. D/S RR Br.
WR-GC-25	-122:44:52.4081	45:34:41.5870	6.7	Lt. D/S RR Br.
WR-BC-26	-122:44:43.0783	45:34:33.8529	6.9	Lt. D/S RR Br.; Comp-26,-28
WR-BC-27	-122:44:37.7302	45:34:33.4267	7.0	Rt. D/S RR Br.; Comp-26,-28
WR-BC-28	-122:44:35.0715	45:34:29.1617	7.1	~ mid-channel; Comp-26,-28
WR-BC-29	-122:44:19.6199	45:34:19.7144	7.5	~ mid-channel
WR-GC-30	-122:43:12.1918	45:33:37.2890	8.5	Swan Is.
WR-GC-31	-122:42:50.2430	45:33:26.9055	8.9	Swan Is.
WR-GC-32	-122:41:40.8248	45:33:02.8328	10.0	Rt. D/S Turning Basin
WR-GC-33	-122:41:35.4903	45:32:55.6554	10.1	Rt. U/S Turning Basin
WR-GC-34	-122:41:48.2905	45:32:56.4872	10.0	Lt. D/S Turning Basin
WR-GC-35	-122:41:42.6042	45:32:52.9740	10.1	Rt. U/S Turning Basin
WR-BC-36	-122:41:26.2867	45:32:45.0068	10.3	~ mid-channel
WR-GC-37	-122:40:49.2764	45:32:13.2822	11.1	Lt. Of C/L
WR-GC-38	-122:40:43.1427	45:32:09.5219	11.2	C/L D/S Turning Basin
WR-GC-39	-122:40:25.7998	45:31:57.7696	11.65	C/L U/S Turning Basin
WR-CD-40	-122:40:37.7078	45:32:08.9439	11.3	Rt. D/S Turning Basin (Core Drill)
WR-CD-41	-122:40:40.4862	45:32:04.8735	11.35	Lt. D/S Turning Basin (Core Drill)
WR-CD-42	-122:40:35.1566	45:31:59.3912	11.5	Lt. U/S Turning Basin (Core Drill)
WR-CD-43	-122:40:26.1315	45:32:03.1942	11.55	Rt. U/S Turning Basin (Core Drill)

Table 5, CRCD Sediment Evaluation Report

Sampled June 2-5, 1997

Columbia River – Physical Analysis

Site	*Water Depth	RM	Mean	Median	Sand	vfsand	Silt	Clay	Vol Solids	Solids	TOC
			mm	mm	% finer			%	%	%	%
CR-BC-01	49.2	6+00	0.47	0.42	11.3	3.8	2.5	0.0	1.0		
CR-BC-02	47.6	6+18	0.27	0.26	47.8	1.3	0.7	0.0	0.6		
CR-BC-03	37.3	6+40	0.31	0.30	32.2	0.5	0.0	0.0	0.6		
CR-BC-04	44.8	9+10	0.16	0.17	90.1	21.7	14.3	3.2	1.5		
CR-BC-05	41.3	11+00	0.19	0.18	83.4	10.2	5.9	1.6	0.9	74.4	0.16
CR-BC-06	39.0	11+40	0.38	0.36	16.9	0.5	0.1	0.0	0.0		
CR-BC-07	32.7	12+45	0.08	0.05	91.3	70.1	59.1	15.4	4.0	66.3	1.29
CR-BC-08	43.6	12+30	0.38	0.36	10.9	0.2	0.0	0.0	0.5		
CR-CB-09	46.9	15+00	0.33	0.32	26.5	0.9	0.5	0.0	0.7		
CR-CB-10	23.0	16+25	0.33	0.32	26.9	1.2	0.5	0.0	0.0		
CR-BC-11/12	50/48	18+35	0.36	0.32	31.9	0.2	0.4	0.0	0.6		
CR-BC-11/12	50/48	20+00	0.29	0.27	41.9	1.3	0.1	0.0	0.6		
CR-BC-13	46.0	20+50	0.52	0.46	3.3	0.4	0.2	0.0	0.6		
CR-BC-14	46.3	22+00	0.41	0.38	9.1	0.7	0.5	0.0	0.0		
CR-BC-15	44.2	23+40	0.44	0.34	37.0	1.9	0.4	0.0	0.7		
CR-BC-16	43.5	24+40	0.36	0.35	12.5	0.2	0.1	0.0	0.7		
CR-BC-17	48.8	27+10	0.85	0.62	4.7	0.5	0.4	0.0	0.6		
CR-BC-18	45.0	28+30	0.22	0.21	70.7	2.1	0.3	0.0	0.0		
CR-BC-19	44.2	29+40	0.18	0.17	94.4	10.3	0.3	0.0	0.7		
CR-BC-20	41.3	32+05	0.33	0.32	22.1	0.5	0.2	0.0	0.6		
CR-BC-21	44.3	33+10	0.66	0.54	7.0	0.5	0.3	0.0	0.6		
CR-BC-22	39.4	35+10	0.33	0.32	27.0	0.6	0.5	0.0	0.7	73.7	<0.05
CR-BC-23	41.9	38+00	0.31	0.30	31.1	0.9	0.5	0.0	0.0		
CR-BC-24	40.0	39+00	0.34	0.33	19.4	0.7	0.4	0.0	0.6	72.8	<0.05
CR-BC-25	39.4	40+45	0.28	0.27	42.2	1.7	0.0	0.0	0.4	77.1	<0.05
CR-BC-26	43.7	42+40	0.33	0.32	25.2	0.9	0.6	0.0	0.6		
CR-BC-27	42.3	44+10	0.33	0.32	24.4	0.5	0.2	0.0	0.0		
CR-BC-28	46.2	45+00	0.41	0.37	10.8	0.7	0.3	0.0	0.0		
CR-BC-29	45.9	46+00	0.28	0.26	46.5	1.4	0.2	0.0	0.6		
CR-BC-30	39.5	47+10	0.35	0.34	11.1	0.2	0.1	0.0	0.0		
CR-BC-31	43.2	48+00	0.61	0.53	3.2	0.7	0.6	0.0	0.5		
CR-BC-32	41.9	51+20	0.78	0.73	1.1	0.2	0.1	0.0	0.0		
CR-BC-33	43.7	54+30	0.65	0.57	7.3	0.5	0.4	0.0	0.0		
CR-BC-34	30.5	56+20	0.37	0.35	14.9	0.6	0.4	0.0	0.4		
CR-BC-35	37.2	57+20	0.41	0.38	8.3	0.3	0.0	0.0	0.4	72.0	<0.05
CR-BC-36	37.2	58+20	0.46	0.41	8.1	0.4	0.3	0.0	0.0		
CR-BC-37	42.1	59+10	0.45	0.40	7.5	0.1	0.0	0.0	0.0		
CR-BC-38	31.1	60+20	0.40	0.37	10.7	0.1	0.0	0.0	0.5		
CR-BC-39	33.1	62+00	0.68	0.48	6.4	0.5	0.4	0.0	0.0		
CR-BC-40	42.1	63+10	0.72	0.55	5.3	0.2	0.1	0.0	0.4	86.5	<0.05
CR-BC-41	37.0	64+00	0.56	0.49	5.3	0.7	0.6	0.0	0.3	87.2	<0.05
CR-BC-42	35.1	65+00	0.49	0.42	6.4	0.1	0.1	0.0	0.0		
CR-BC-43	38.1	65+40	1.17	0.86	4.0	0.2	0.1	0.0	0.0		
CR-BC-44 **	45.1	66+10	0.34	0.33	17.4	0.7	0.5	0.0	0.2		
CR-BC-46	36.1	67+15	2.22	1.79	0.3	0.1	0.1	0.0	0.0		

Note: The symbol " < " denotes a non-detect at the numerical level listed.

*Water Depth corrected to Columbia River Datum.

Table 5, CRCD Sediment Evaluation Report **Sampled June 2-5, 1997**

Columbia River – Physical Analysis

Site	*Water Depth	RM	Mean mm	Median mm	Sand % finer	vfsand % finer	Silt % finer	Clay %	Vol Solids %	Solids %	TOC %
CR-BC-47	46.1	70+45	0.34	0.33	23.4	0.4	0.3	0.0	0.4		
CR-BC-48	46.2	71+45	0.74	0.69	2.4	0.9	0.8	0.0	0.6		
CR-BC-49	40.2	73+25	1.33	1.03	0.3	0.1	0.1	0.0	0.5		
CR-BC-50	43.2	74+50	0.25	0.23	58.5	7.6	0.5	0.0	0.5		
CR-BC-51	45.2	75+50	0.53	0.46	2.0	0.2	0.2	0.0	0.3		
CR-BC-52	40.2	76+50	0.36	0.35	15.7	0.3	0.1	0.0	0.5	73.4	<0.05
CR-BC-53	44.2	79+20	0.87	0.76	3.8	0.5	0.2	0.0	0.6		
CR-BC-54	39.2	80+35	1.77	1.33	2.6	0.2	0.2	0.0	0.5		
CR-BC-55	46.2	82+08	0.58	0.45	9.0	0.2	0.0	0.0	0.5	73.9	<0.05
CR-BC-56	42.2	83+00	0.70	0.57	4.8	0.3	0.2	0.0	0.7	75.7	0.07
CR-BC-57	12.2	83+34	0.10	0.10	98.2	66.9	24.6	3.7	2.6	66.2	0.76
CR-BC-58	48.2	84+31	0.35	0.34	19.1	0.5	0.2	0.0	0.0		
CR-BC-59	43.2	85+20	0.72	0.66	2.8	0.4	0.3	0.0	0.4	87.4	<0.05
CR-BC-60	36.2	85+45	0.65	0.62	4.5	0.7	0.6	0.0	0.7		
CR-BC-61	29.2	86+40	0.86	0.70	5.5	0.6	0.5	0.0	0.6	80.0	<0.05
CR-BC-62	43.2	88+00	0.72	0.69	1.7	0.5	0.4	0.0	0.5		
CR-BC-63	36.2	89+00	0.27	0.25	48.7	2.1	0.5	0.0	0.2		
CR-BC-64	40.2	90+00	0.36	0.35	15.0	0.6	0.3	0.0	0.0		
CR-BC-65	42.2	91+00	0.72	0.63	3.8	0.4	0.3	0.0	0.5		
CR-BC-66/67	39.2,44.2	92+00	0.71	0.66	3.1	0.4	0.3	0.0	0.6		
CR-BC-66/67	39.2,44.2	93+00	0.30	0.29	34.2	0.9	0.2	0.0	0.4		
CR-BC-68	43.2	93+50	0.42	0.39	6.7	0.3	0.1	0.0	0.4		
CR-BC-69	46.1	95+00	0.72	0.66	4.0	0.5	0.4	0.0	0.0		
CR-BC-70	40.1	96+00	0.51	0.42	16.1	0.4	0.0	0.0	0.6		
CR-BC-71	48.1	97+00	1.24	0.96	0.9	0.2	0.1	0.0	0.7		
CR-BC-72	48.1	98+00	0.86	1.70	0.2	0.1	0.0	0.0	0.5		
CR-BC-73	40.1	99+20	0.77	0.63	8.0	0.8	0.4	0.0	0.6	74.3	0.06
CR-BC-74	50.1	99+20	0.99	0.84	1.1	0.3	0.2	0.0	0.8	91.2	<0.05
CR-BC-75	52.1	99+20	3.07	0.83	3.6	0.8	0.5	0.0	0.7	75.2	0.12
CR-BC-75A	52.1	99+20	0.04	0.03	98.3	96.7	77.3	10.5	4.6		
CR-BC-76	47.1	100+20	0.08	0.03	87.7	79.3	68.2	12.3	7.1	53.0	2.26
CR-BC-77	44.1	100+45	0.58	0.51	4.5	0.3	0.1	0.0	0.5		
CR-BC-78	56.1	101+25	0.51	0.40	20.0	0.7	0.2	0.0	0.7		
CR-BC-79	48.1	102+25	0.68	0.41	24.3	0.5	0.1	0.0	0.5		
CR-BC-80	45.1	103+12	0.44	0.35	31.2	0.6	0.1	0.0	0.6	73.1	0.06
CR-BC-81	46.1	103+45	0.31	0.29	39.6	0.6	0.1	0.0	0.5		
CR-BC-82	46.1	103+45	0.33	0.32	28.1	0.4	0.1	0.0	0.8		
CR-BC-83	45.1	103+45	0.32	0.31	26.4	0.4	0.3	0.0	0.9		
CR-BC-84	46.1	104+10	0.34	0.32	30.6	0.6	0.1	0.0	0.6	74.9	0.08
CR-BC-85	45.1	104+30	0.35	0.33	26.0	0.3	0.0	0.0	0.6	76.4	0.07
CR-BC-86	30.1	105+25	1.04	0.82	1.2	0.1	0.1	0.0	0.5	84.1	0.07
CR-BC-87	36.1	105+40	1.30	1.11	0.4	0.1	0.0	0.0	0.5		
CR-BC-88	39.1	106+20	0.89	0.73	1.1	0.1	0.0	0.0	0.5	88.9	<0.05
CR-BC-89	34.1	106+20	0.59	0.51	2.9	0.3	0.3	0.0	0.6		

Note: The symbol " < " denotes a non-detect at the numerical level listed.
*Water Depth corrected to Columbia River Datum.

Table 6, CRCD
Sediment Evaluation Report

Columbia River- Metals Analysis

Site	RM	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	AVS
					mg/kg (ppm)						%
CR-BC-05	11+00	3.0	<0.8	11.0	7.0	4.0	<0.05	13.0	<0.6	40.0	0.7
CR-BC-07	12+45	3.0	<0.8	14.0	17.0	7.0	<0.05	17.0	<0.6	66.0	61
CR-BC-22	35+10	2.0	<0.8	7.0	7.0	3.0	<0.05	10.0	<0.6	46.0	<0.7
CR-BC-24	39+00	2.0	<0.8	6.0	6.0	2.0	<0.05	12.0	<0.6	38.0	<0.7
CR-BC-25	40+45	1.0	<0.8	6.0	6.0	2.0	<0.05	10.0	<0.6	36.0	<0.7
CR-BC-35	57+20	2.0	<0.8	4.0	8.0	2.0	<0.05	8.0	<0.6	34.0	<0.7
CR-BC-40	63+10	1.0	<0.8	3.0	8.0	1.0	<0.05	7.0	<0.6	28.0	<0.6
CR-BC-41	64+00	2.0	<0.8	4.0	6.0	2.0	<0.05	6.0	<0.6	32.0	<0.6
CR-BC-52	76+50	2.0	<0.8	6.0	5.0	3.0	<0.05	7.0	<0.6	43.0	<0.7
CR-BC-55	82+08	2.0	<0.8	5.0	6.0	3.0	<0.05	9.0	<0.6	40.0	<0.7
CR-BC-56	83+00	2.0	<0.8	5.0	6.0	3.0	<0.05	9.0	<0.6	38.0	<0.7
CR-BC-57	83+34	2.0	<0.8	21.0	21.0	8.0	<0.05	21.0	1.0	85.0	0.9
CR-BC-59	85+20	2.0	<0.8	4.0	5.0	2.0	<0.05	7.0	<0.6	28.0	<0.6
CR-BC-61	86+40	2.0	<0.8	4.0	4.0	2.0	<0.05	7.0	<0.6	32.0	<0.7
CR-BC-73	99+20	2.0	<0.8	6.0	9.0	2.0	<0.05	7.0	<0.6	38.0	<0.7
CR-BC-74	99+20	2.0	<0.8	5.0	7.0	2.0	<0.05	5.0	<0.6	32.0	<0.7
CR-BC-75	99+20	1.0	<0.8	4.0	7.0	2.0	<0.05	6.0	<0.6	28.0	<0.7
CR-BC-76	100+20	3.0	<0.8	24.0	33.0	10.0	0.1	22.0	<0.6	83.0	7.5
CR-BC-80	103+12	2.0	<0.8	6.0	6.0	4.0	<0.05	9.0	<0.6	57.0	<0.7
CR-BC-84	104+10	2.0	<0.8	7.0	9.0	5.0	<0.05	10.0	<0.6	60.0	<0.7
CR-BC-85	104+30	2.0	<0.8	6.0	7.0	5.0	<0.05	8.0	<0.6	54.0	<0.7
CR-BC-86	105+25	1.0	<0.8	4.0	7.0	2.0	<0.05	6.0	<0.6	33.0	<0.7
CR-BC-88	106+20	1.0	<0.8	3.0	5.0	2.0	<0.05	6.0	<0.6	31.0	<0.7
Average Value		1.9	<0.8	7.2	8.8	3.4	<0.05	9.7	0.04	43.6	
Maximum Value		3.0	<0.8	24.0	33.0	10.0	0.1	22.0	1.0	85.0	
Screening Levels		57.0	5.10	NA	390.0	450.0	0.41	140.0	6.10	410.0	

Note: The symbol " < " denotes a non-detect at the numerical level listed.

Table 7, CRCD Sediment Evaluation Report

Columbia River- Pesticides and PCBs – ug/kg (ppb)

Site	RM	Aldrin	DDT	DDE	DDD	Total DDT	Aroclor 1254	Aroclor 1260	Total PCBs
CR-BC-05	11+00	<2	<2	<2	<2	ND	<10	<10	ND
CR-BC-07	12+45	<2	**3.0**	**0.9**	**0.5**	**4.4**	<10	<10	ND
CR-BC-22	35+10	<2	<2	<2	<2	ND	<10	<10	ND
CR-BC-24	39+00	<2	<2	<2	<2	ND	<10	<10	ND
CR-BC-25	40+45	<2	<2	<2	<2	ND	<10	<10	ND
CR-BC-35	57+20	<2	<2	<2	<2	ND	<10	<10	ND
CR-BC-40	63+10	<2	<2	<2	<2	ND	<10	<10	ND
CR-BC-41	64+00	<2	<2	<2	<2	ND	<10	<10	ND
CR-BC-52	76+50	<2	<2	<2	<2	ND	<10	<10	ND
CR-BC-55	82+08	<2	<2	<2	<2	ND	<10	<10	ND
CR-BC-56	83+00	<2	<2	<2	<2	ND	<10	<10	ND
CR-BC-57	83+34	<2	**0.3**	**0.4**	**0.6**	**1.3**	<10	<10	ND
CR-BC-59	85+20	<2	<2	<2	<2	ND	<10	<10	ND
CR-BC-61	86+40	<2	<2	<2	<2	ND	<10	<10	ND
CR-BC-73	99+20	<2	<2	<2	<2	ND	<10	<10	ND
CR-BC-74	99+20	**0.2**	<2	<2	<2	ND	<10	<10	ND
CR-BC-75	99+20	<2	<2	<2	<2	ND	<10	<10	ND
CR-BC-76	100+20	**0.6**	<2	**2.0**	**2.0**	**4.0**	**24.0**	**37.0**	**61.0**
CR-BC-80	103+12	<2	<2	<2	<2	ND	<10	<10	ND
CR-BC-84	104+10	<2	<2	<2	<2	ND	<10	<10	ND
CR-BC-85	104+30	<2	<2	<2	<2	ND	<10	<10	ND
CR-BC-86	105+25	<2	<2	<2	<2	ND	<10	<10	ND
CR-BC-88	106+20	<2	<2	<2	<2	ND	<10	<10	ND
Average Value		0.0	0.1	0.1	0.1	0.4	1.0	1.6	2.7
Maximum Value		0.6	3.0	2.0	2.0	4.4	24.0	37.0	61.0
Screening Levels		10.0				6.9			130.0

Note: The symbol " < " denotes a non-detect at the numerical level listed.

Table 8, CRCD
Sediment Evaluation Report

Columbia River- Low PAHs – ug/kg (ppb)

Site	RM	Napthalene	2-Methyl napthalene	Acenaph-thalene	Acenaph-thene	Fluorene	Phenan-threne	Anthracene	Total Low PAHs
CR-BC-05	11+00	**2.0**	**5.0**	<5	<5	<5	**1.0**	<5	**8.0**
CR-BC-07	12+45	**5.0**	**4.0**	**0.8**	**3.0**	**2.0**	**8.0**	**2.0**	**27.0**
CR-BC-22	35+10	**2.0**	**3.0**	<5	<5	<5	**0.9**	<5	**6.0**
CR-BC-24	39+00	**1.0**	**2.0**	<5	<5	<5	<5	<5	**3.0**
CR-BC-25	40+45	<5	<5	**0.3**	**0.6**	**1.0**	**2.0**	**1.0**	**5.0**
CR-BC-35	57+20	<5	<5	<5	<5	<5	<5	<5	**0.0**
CR-BC-40	63+10	**2.0**	**3.0**	**0.5**	**0.7**	**1.0**	**1.0**	**0.7**	**10.0**
CR-BC-41	64+00	<5	<5	<5	<5	<5	<5	<5	**0.0**
CR-BC-52	76+50	**1.0**	**2.0**	<5	<5	<5	<5	<5	**3.0**
CR-BC-55	82+08	<5	<5	<5	<5	<5	<5	<5	**0.0**
CR-BC-56	83+00	**4.0**	**5.0**	**1.0**	**2.0**	**1.0**	**3.0**	**2.0**	**19.0**
CR-BC-57	83+34	**15.0**	**7.0**	**3.0**	**6.0**	**4.0**	**31.0**	**8.0**	**76.0**
CR-BC-59	85+20	**1.0**	**4.0**	**0.2**	**0.5**	<5	**0.9**	<5	**7.0**
CR-BC-61	86+40	**2.0**	**4.0**	<5	<5	<5	**0.8**	<5	**7.0**
CR-BC-73	99+20	**0.8**	**0.6**	<5	<5	<5	<5	<5	**1.0**
CR-BC-74	99+20	<5	<5	<5	<5	<5	<5	<5	**0.0**
CR-BC-75	99+20	**1.0**	**2.0**	<5	<5	<5	<5	<5	**3.0**
CR-BC-76	100+20	**20.0**	**10.0**	**3.0**	**6.0**	**9.0**	**49.0**	**9.0**	**112.0**
CR-BC-80	103+12	**2.0**	**2.0**	<5	**0.5**	**0.7**	**2.0**	**0.8**	**10.0**
CR-BC-84	104+10	**2.0**	**3.0**	<5	<5	<5	**0.9**	<5	**6.0**
CR-BC-85	104+30	**1.0**	**0.7**	<5	<5	**0.6**	**1.0**	**0.7**	**5.0**
CR-BC-86	105+25	**7.0**	**0.6**	<5	<5	<5	<5	<5	**2.0**
CR-BC-88	106+20	**0.7**	**0.6**	<5	<5	**0.7**	**2.0**	**0.8**	**6.0**
Average Value		3.0	2.5	0.4	0.8	0.9	4.5	1.1	13.7
Maximum Value		20.0	10.0	3.0	6.0	9.0	49.0	9.0	112.0
Screening Levels		2,100.0	670.0	560.0	500.0	540.0	1,500.0	960.0	5,200.0

Note: The symbol " < " denotes a non-detect at the numerical level listed.

Table 9, CRCD Sediment Evaluation Report

Columbia River – High PAHs – ug/kg (ppb)

Site	RM	Fluor-anthene	Pyrene	Benzo-anthracene	Chrysene	Benzo(b,k) fluoranthene	Benzo(a) pyrene	Ideno(1,2,3-cd) pyrene	Dibenz(a,h) anthracene	Benzo(g,h,i) perylene	Total High PAHs
CR-BC-05	11+00	**2.0**	**1.0**	<5	**0.8**	**1.0**	**0.7**	**0.7**	**0.9**	<5	**7.0**
CR-BC-07	12+45	**12.0**	**14.0**	**7.0**	**9.0**	**7.0**	**9.0**	**8.0**	**1.0**	**9.0**	**76.0**
CR-BC-22	35+10	<5	<5	**0.7**	<5	<5	<5	<5	<5	<5	**1.0**
CR-BC-24	39+00	<5	<5	<5	<5	<5	<5	<5	<5	<5	**0.0**
CR-BC-25	40+45	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**	**1.0**	**1.0**	**2.0**	**16.0**
CR-BC-35	57+20	**0.7**	<5	<5	**0.7**	<5	<5	<5	<5	**0.8**	**3.0**
CR-BC-40	63+10	**0.9**	**0.7**	**1.0**	**1.0**	**1.8**	**0.7**	**0.7**	<5	**1.0**	**0.0**
CR-BC-41	64+00	<5	<5	<5	<5	<5	<5	<5	<5	**0.5**	**1.0**
CR-BC-52	76+50	**0.7**	<5	<5	<5	<5	<5	<5	<5	**0.9**	**0.0**
CR-BC-55	82+08	<5	<5	<5	**0.7**	<5	<5	<5	<5	**3.0**	**0.0**
CR-BC-56	83+00	**5.0**	**4.0**	**4.0**	**4.0**	**8.0**	**4.0**	**3.0**	**3.0**	**12.0**	**0.0**
CR-BC-57	83+34	**51.0**	**64.0**	**36.0**	**46.0**	**79.0**	**70.0**	**56.0**	**6.0**	**61.0**	**61.0**
CR-BC-59	85+20	**0.8**	<5	<5	**0.6**	**0.6**	**0.6**	<5	<5	**0.9**	**4.0**
CR-BC-61	86+40	<5	<5	<5	<5	<5	<5	<5	<5	<5	**0.0**
CR-BC-73	99+20	<5	<5	<5	<5	<5	<5	<5	<5	<5	**0.0**
CR-BC-74	99+20	<5	<5	<5	<5	<5	<5	<5	<5	<5	**0.0**
CR-BC-75	99+20	<5	<5	<5	<5	<5	<5	<5	<5	**1.0**	**1.0**
CR-BC-76	100+20	**87.0**	**77.0**	**38.0**	**50.0**	**67.0**	**37.0**	**20.0**	**4.0**	**27.0**	**407.0**
CR-BC-80	103+12	**2.0**	<5	<5	**0.6**	<5	<5	<5	<5	<5	**3.0**
CR-BC-84	104+10	**1.0**	**2.0**	**0.8**	**0.9**	**1.4**	**1.0**	**1.0**	<5	**1.0**	**9.0**
CR-BC-85	104+30	**2.0**	<5	**2.0**	**2.0**	**6.0**	**2.0**	**2.0**	**1.0**	**2.0**	**19.0**
CR-BC-86	105+25	<5	<5	<5	<5	<5	<5	<5	<5	**2.0**	**2.0**
CR-BC-88	106+20	**2.0**	<5	**2.0**	**2.0**	**5.0**	**2.0**	**2.0**	**1.0**	**5.0**	**21.0**
Average Value		7.4	7.2	4.1	5.2	7.8	5.6	4.1	0.8	5.6	27.4
Maximum Value		87.0	77.0	38.0	50.0	79.0	70.0	56.0	6.0	61.0	407.0
Screening Levels		1,700.0	2,600.0	1,300.0	1,400.0	3,200.0	1,600.0	600.0	230.0	670.0	12,000

Note: The symbol " < " denotes a non-detect at the numerical level listed.

Table 10, CRCD Sediment Evaluation Report

Columbia River- P450 RGS (Dioxin/Furan Screen)

Site	RM	6 Hour B(a)P Eq (ug/g)	TEQ (ng/g)	16 Hour B(a)P Eq (ug/g)	TEQ (ng/g)	Ratio	Primary* Contaminates
CR-BC-05	11+00	1.90	0.10	0.50	0.03	4	both
CR-BC-07	12+45	3.00	0.20	2.40	0.10	1	both
CR-BC-22	35+10	1.10	0.10	0.20	0.01	7	PAHs
CR-BC-24	39+00	0.50	0.03	0.10	0.01	4	both
CR-BC-25	40+45	0.70	0.04	0.10	0.01	9	PAHs
CR-BC-35	57+20	1.40	0.10	0.10	0.01	10	PAHs
CR-BC-40	63+10	0.70	0.02	0.10	0.01	4	both
CR-BC-41	64+00	0.70	0.04	0.20	0.01	5	both
CR-BC-52	76+50	0.70	0.04	0.10	0.01	7	PAHs
CR-BC-55	82+08	0.70	0.04	0.10	0.01	5	both
CR-BC-56	83+00	0.60	0.04	0.20	0.01	3	both
CR-BC-57	83+34	3.60	0.20	3.70	0.20	1	both
CR-BC-59	85+20	0.50	0.03	0.10	0.01	6	PAHs
CR-BC-61	86+40	1.00	0.10	0.10	0.01	12	PAHs
CR-BC-73	99+20	1.70	0.10	0.10	0.01	14	PAHs
CR-BC-74	99+20	1.40	0.10	0.20	0.01	7	PAHs
CR-BC-75	99+20	2.70	0.20	0.40	0.03	6	PAHs
CR-BC-76**	100+20	3.90	0.20	8.50	0.50	0.5	PCBs/dioxins
CR-BC-80	103+12	5.50	0.30	0.90	0.10	6	PAHs
CR-BC-84	104+10	4.20	0.30	1.00	0.10	4	both
CR-BC-85	104+30	4.70	0.30	1.40	0.10	3	both
CR-BC-86	105+25	0.30	0.02	0.10	0.01	3	both
CR-BC-88	106+20	0.60	0.03	0.10	0.01	7	PAHs

*Based on ratio of 6hr/16 hr where ratio > 5 = PAHs; ratio 5 to 1 = both PAHs and chlorinated compounds; and ratio < 1 = chlorinated compounds.

** See text page 7- P-450.

Note: The term "both" indicates that PAHs and Chlorinated Compounds have been detected; if the corresponding sample analysis show PAHs & PCBs present in significant amounts, it is not likely that Dioxins are present in that sample.

ug B(a)P Eq = PAHs detected by P450 RGS.
TEQ = Chlorinated hydrocarbons detected by P450 RGS.

Table 11, CRCD, Sampled July 22-25, 1997 Willamette River – Physical Analysis

Site	Depth Sediment Sample	*Water Depth	RM	Mean mm	Median mm	Sand %finer	vfsand %finer	Silt	Clay	%fines	Vol Solids %	Solids %	TOC %
WR-BC-01	8 inches	43.6	0.10	0.47	0.30	41.7	13.1	5.2	0.0	5.2	0.8	75.1	0.13
WR-A	8 inches	43.6	0.10	0.65	0.28	45.2	17.4	7.4	0.0	7.4	0.9	73.0	0.16
WR-GC-02A	0-6.0 feet	41.9	0.10	0.16	0.15	81.8	39.7	21.2	1.8	23.0	1.4	69.1	0.59
WR-GC-02B	6.0-9.9 feet		0.10	0.49	0.30	41.9	9.3	2.4	0.0	2.4	0.7	77.0	0.14
WR-BC-03	8 inches	43.7	0.40	0.24	0.21	62.2	20.1	7.2	0.0	7.2	1.8	66.6	0.38
WR-GC-04A	0-6.0 feet	24.4	0.80	0.08	0.06	91.0	79.2	51.2	3.8	55.0	3.0	63.7	0.99
WR-GC-04B	6.0-7.0 feet		0.80	0.06	0.03	95.0	87.4	73.0	5.6	78.6	3.6	62.3	0.92
WR-GC-04Z	7.0-7.6 feet		0.80	0.07	0.05	92.1	80.8	60.6	4.2	64.8	3.0		
WR-GC-05A	0-6.0 feet	39.0	0.80	0.05	0.03	96.9	89.0	74.9	7.5	82.4	3.6	66.7	0.99
WR-GC-05B	6.0-7.0 feet		0.80	0.03	0.02	98.1	95.6	91.6	8.9	100.5	3.6	68.6	0.88
WR-GC-06A	0-6.0 feet	42.5	0.95	0.05	0.03	97.8	92.7	71.8	2.6	74.4	2.6	55.0	0.26
WR-GC-06B	6.0-9.0 feet		0.95	0.05	0.03	99.4	94.1	71.6	7.2	78.8	2.5	53.4	0.06
WR-GC-06Z	9.0-10.5 feet		0.95	0.02	0.02	99.3	98.9	93.9	3.1	97.0	2.5		
WR-BC-07	9.5 inches	29.8	1.60	0.04	0.04	98.4	93.5	75.3	4.7	80.0	4.2	51.5	1.33
WR-BC-08	10 inches	45.9	1.70	0.07	0.04	93.3	83.6	68.5	3.4	71.9	3.6	54.2	1.20
WR-BC-09	10 inches	43.7	2.05	0.06	0.04	97.7	84.2	69.1	5.5	74.6	3.9	53.9	1.26
WR-BC-10	9.5 inches	43.1	2.45	0.07	0.04	89.8	80.4	67.3	4.9	72.2	4.9	47.1	1.59
WR-B	9.5 inches	43.1	2.45	0.13	0.04	89.6	79.6	65.2	5.7	70.9	5.0	48.9	1.84
WR-GC-11A	0-6.0 feet	44.3	2.90	0.08	0.06	92.3	73.9	52.1	4.1	56.2	4.7	55.2	1.62
WR-GC-11Z	6.0-11.0 feet		2.90	0.04	0.03	98.5	92.6	81.3	6.6	87.9	4.1		
WR-BC-12,13,14	9, 10, 8.5 inch	46,44,44	3.40	0.19	0.13	65.6	48.6	38.2	5.7	43.9	3.5	70.1	0.37
WR-BC-15	9.5 inches	43.3	3.80	0.07	0.04	92.0	80.2	72.1	6.9	79.0	5.3	46.2	1.78
WR-BC-16,17	9, 9 inches	42.3,42.4	4.10	0.27	0.30	33.4	20.9	19.1	2.1	21.2	1.4	57.9	0.54
WR-GC-18A	0-6.0 feet	38.2	5.10	0.05	0.04	95.9	89.1	73.4	6.7	80.1	7.0	52.6	2.26
WR-GC-18Z	6.0-8.6 feet		5.10	0.08	0.05	89.7	78.0	62.9	4.6	67.5	7.0		
WR-GC-19A	0-6.0 feet	80.0	5.10	0.36	0.35	15.6	0.9	0.4	0.0	0.4	1.2	77.9	0.07
WR-BC-20	9.5 inches	46.3	5.15	0.47	0.42	10.8	7.9	5.9	0.0	5.9	2.2	72.7	0.38
WR-BC-21	8.5 inches	46.0	5.90	0.48	0.42	4.7	2.5	1.9	0.0	1.9	1.4	76.6	0.61
WR-BC-22	9 inches	43.5	6.20	0.60	0.50	4.4	0.9	0.5	0.0	0.5	2.3	82.2	0.77
WR-BC-23	7 inches	43.6	6.50	0.42	0.39	7.0	1.4	0.6	0.0	0.6	1.1	77.8	0.52
WR-GC-24A	0-6.0 feet	45.0	6.70	1.24	0.09	84.5	61.8	38.4	3.7	42.1	4.2	60.9	1.91
WR-GC-24B	6.0-7.0 feet		6.70	9.20	0.30	46.0	23.8	9.1	1.4	10.5	1.4	81.4	1.85
WR-GC-24Z	7.0-7.7 feet		6.70	10.01	1.57	9.5	4.7	2.7	0.0	2.7	0.9		
WR-GC-25A	0-2.0 feet	44.2	6.70	0.03	0.03	94.7	92.9	85.3	7.9	93.2	6.3	54.8	2.08
WR-GC-25Z	2.0-4.4 feet		6.70	0.36	0.35	13.7	5.4	3.4	0.0	3.4	1.5		
WR-BC-26,27,28	9, 7.5, 10 inch	44,47,44	6.90	0.30	0.32	28.2	18.6	11.6	0.0	11.6	2.5	70.6	0.18
WR-BC-29	10 inches	44.9	7.50	0.17	0.09	67.3	57.0	42.0	2.4	44.4	3.9	58.4	1.18
WR-C	10 inches	44.9	7.50	0.16	0.09	69.9	59.5	39.9	2.9	42.8	4.1	58.4	1.32
WR-GC-30A	0-5.0 feet	41.6	8.50	0.07	0.06	95.6	80.8	51.1	6.3	57.4	4.7	57.3	1.80
WR-GC-30Z	5.0-9.7 feet		8.50	0.09	0.06	94.2	70.3	49.8	7.5	57.3	5.8		
WR-GC-31A	0-5.0 feet	41.5	8.90	0.10	0.09	95.7	66.5	38.5	5.5	44.0	4.9	61.2	1.68
WR-GC-31Z	5.0-6.0 feet		8.90	0.06	0.05	96.0	85.9	59.3	7.8	67.1	5.3		
WR-GC-32A	0-6.0 feet	41.0	10.00	0.08	0.05	93.4	76.8	52.7	7.2	59.9	5.1	60.5	1.66
WR-GC-32Z	6.0-7.3 feet		10.00	0.03	0.03	98.2	96.5	90.6	11.4	102.0	3.1		
WR-GC-33A	0-5.0 feet	43.1	10.10	0.08	0.06	94.3	77.6	54.7	4.5	59.2	5.0	59.7	1.64
WR-GC-33Z	5.0-7.4 feet		10.10	0.04	0.04	99.4	98.5	85.9	5.5	91.4	3.5		
WR-GC-34A	0-5.0 feet	46.2	10.00	0.21	0.15	64.4	46.4	31.8	4.1	35.9	4.7	61.9	1.96
WR-GC-35A	0-5.0 feet	42.7	10.10	0.11	0.05	85.1	70.3	59.3	7.8	67.1	6.9	55.8	2.33
WR-GC-35Z	5.0-8.9 feet		10.10	0.05	0.04	95.9	90.1	74.1	7.3	81.4	8.6		
WR-BC-36	9.7 inches	45.4	10.30	0.21	0.19	59.4	38.1	27.9	4.0	31.9	3.8	59.8	1.43
WR-GC-37A	0-4.0 feet	45.4	11.10	0.59	0.53	3.1	0.3	0.1	0.0	0.1	0.9	81.3	0.07
WR-GC-38A	0-2.0 feet	42.5	11.20	0.59	0.55	4.2	1.1	0.7	0.0	0.7	1.2	71.2	1.04
WR-GC-38Z	2.0-4.1 feet		11.20	0.76	0.58	2.8	0.3	0.1	0.0	0.1	0.9		
WR-GC-39A	0-4.0 feet	40.0	11.65	1.07	0.48	6.3	0.7	0.4	0.0	0.4	1.3	78.1	0.77
WR-GC-39Z	4.0-5.0 feet		11.65	0.59	0.57	1.9	0.3	0.2	0.0	0.2	0.8		
WR-CD-40A	0-2.0 feet	45.6	11.30	0.72	0.62	2.6	0.4	0.2	0.0	0.2	1.1	82.0	0.30
WR-CD-40Z	2.0-3.5 feet	38.3	11.30	1.71	0.74	1.6	0.2	0.1	0.0	0.1	1.0		
WR-CD-41A	0-6.0 feet	38.3	11.35	0.35	0.34	15.3	3.3	1.4	0.0	1.4	1.4	73.2	0.44
WR-CD-41B	6.0-7.0 feet		11.35	0.18	0.15	66.6	45.5	38.4	3.6	42.0	5.2	60.2	2.74
WR-CD-41Z	7.0-8.8 feet		11.35	1.01	0.25	50.6	24.5	15.4	2.2	17.6	7.1		
WR-CD-42A	0-6.0 feet	24.7	11.50	0.12	0.10	92.0	59.0	39.6	2.6	42.2	4.7	59.5	1.51
WR-CD-42B	6.0-12.0 feet		11.50	0.11	0.08	89.3	58.4	45.7	5.9	51.6	4.5	92.8	1.44
WR-CD-42C	12.0-18.0 feet		11.50	0.15	0.14	78.6	45.9	36.0	4.5	40.5	5.5	62.6	1.98
WR-CD-42D	18.0-20.0 feet		11.50	0.18	0.16	68.5	42.9	34.6	3.9	38.5	5.5	63.8	2.09
WR-CD-43A	0-6.0 feet	48	11.55	0.48	0.39	11.3	0.7	0.2	0.0	0.2	1.5	86.5	0.38
WR-D	0-6.0 feet		11.55	0.48	0.39	13.0	0.9	0.5	0.0	0.5	1.3	89.2	1.21
WR-CD-43B	6.0-12.0 feet		11.55	3.71	0.63	5.3	0.3	0.2	0.0	0.2	1.2	89.7	0.10
WR-CD-43Z	12.0-14.0 feet		11.55	4.45	1.12	4.7	0.3	0.1	0.0	0.1	1.1		

Note: The following are field replicate pairs: WR-BC-01, WR-A; WR-BC-10, WR-B; WR-BC-29, WR-C; WR-BC-43A, WR-D.
*Water depth in feet corrected to Columbia River Datum .

Table 12, CRCD Sediment Evaluation Report

Willamette River – Metals Analysis

Site	Date	RM	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	TBT	AVS
			mg/kg (ppm)									ppb	%
WR-BC-01	24-Jul-97	0.10	1.0	0.19	10.5	8.0	5.0	0.03	9.0	0.04	51.0	<0.05	<0.7
WR-A	24-Jul-97	0.10	1.2	0.21	11.9	8.8	5.3	0.02	9.4	0.05	52.6	<0.05	<0.7
WR-GC-02A	24-Jul-97	0.10	2.4	0.50	15.9	13.2	10.1	0.06	12.8	0.08	92.1		19.0
WR-GC-02B	24-Jul-97	0.10	1.1	0.10	12.2	8.9	3.4	0.04	9.2	0.04	34.5		0.8
WR-BC-03	24-Jul-97	0.40	2.7	0.33	17.8	16.3	10.5	0.03	16.7	0.11	89.5	<0.05	<0.8
WR-GC-04A	24-Jul-97	0.80	5.8	1.36	26.8	24.0	27.0	0.13	18.1	0.18	166.0		53.0
WR-GC-04B	24-Jul-97	0.80	5.6	1.62	24.3	26.4	23.7	0.12	17.8	0.15	138.0		30.0
WR-GC-05A	24-Jul-97	0.80	3.2	0.23	25.2	24.6	9.1	0.07	19.8	0.14	61.2		4.8
WR-GC-05B	24-Jul-97	0.80	0.6	0.16	24.9	24.5	7.1	0.03	19.3	0.16	53.6		4.8
WR-GC-06A	24-Jul-97	0.95	1.3	0.13	11.4	14.5	3.7	0.03	9.3	0.08	30.4		0.8
WR-GC-06B	24-Jul-97	0.95	1.3	0.03	6.6	9.4	1.2	0.01	4.4	0.03	10.8		1.9
WR-BC-07	24-Jul-97	1.60	0.6	0.93	27.6	30.4	19.6	0.08	19.7	0.21	139.0	<0.05	65.0
WR-BC-08	24-Jul-97	1.70	2.5	0.65	28.9	28.2	15.9	0.06	20.9	0.16	115.0	<0.05	14.8
WR-BC-09	24-Jul-97	2.05	3.5	0.54	28.4	27.2	14.8	0.06	19.7	0.16	101.0	<0.05	2.9
WR-BC-10	24-Jul-97	2.45	4.0	0.71	33.0	36.7	20.7	0.09	22.5	0.28	137.0	0.10	47.0
WR-B	24-Jul-97	2.45	3.5	0.67	26.8	33.0	19.7	0.08	19.7	0.25	128.0	0.10	47.0
WR-GC-11A	24-Jul-97	2.90	2.5	0.43	28.1	31.6	22.0	0.09	21.7	0.25	120.0		10.2
WR-BC-12, 13, 14	24-Jul-97	3.40	2.6	0.22	20.4	20.8	11.6	0.07	17.4	0.10	79.1	<0.05	4.6
WR-BC-15	24-Jul-97	3.80	2.8	0.41	33.2	39.0	21.2	0.08	23.7	0.31	131.0	0.14	17.5
WR-BC-16,17	24-Jul-97	4.10	3.5	0.16	21.3	20.9	9.2	0.17	19.7	0.10	76.5	<0.05	2.2
WR-GC-18A	22-Jul-97	5.10	4.5	0.27	32.5	36.7	25.3	0.08	23.5	0.27	112.0		17.9
WR-GC-19A	22-Jul-97	5.10	1.4	0.05	15.1	13.5	2.8	0.03	19.2	0.06	41.6		<0.7
WR-BC-20	24-Jul-97	5.15	2.1	0.09	16.7	15.2	9.0	0.11	14.0	0.07	54.9	<0.05	0.9
WR-BC-21	24-Jul-97	5.90	2.7	0.06	17.0	16.4	4.5	0.02	16.0	0.06	53.6	**0.25**	<0.7
WR-BC-22	24-Jul-97	6.20	3.3	0.05	14.5	12.2	4.7	0.01	14.8	0.06	45.2		3.6
WR-BC-23	24-Jul-97	6.50	1.4	0.05	15.8	13.1	3.9	0.03	14.7	0.06	49.3	**0.42**	<0.7
WR-GC-24A	22-Jul-97	6.70	2.1	0.20	20.4	25.3	14.8	0.17	22.9	0.21	85.5		34.0
WR-GC-24B	22-Jul-97	6.70	2.4	0.09	12.5	15.7	3.6	0.02	20.6	0.06	39.6		<0.7
WR-GC-25A	24-Jul-97	6.70	3.7	0.33	30.7	36.3	27.7	0.18	22.2	0.35	150.0		19.0
WR-BC-26, 27, 28	24-Jul-97	6.90	2.1	0.08	17.7	16.4	5.9	0.03	16.1	0.08	51.5	0.01	0.8
WR-BC-29	24-Jul-97	7.50	3.9	0.17	25.0	26.9	16.8	0.08	20.8	0.18	110.0	0.02	11.4
WR-C	24-Jul-97	7.50	2.7	0.17	27.9	27.6	17.5	0.06	21.2	0.19	107.0	0.02	1.5
WR-GC-30A	22-Jul-97	8.50	2.8	0.22	32.1	32.3	22.8	0.07	23.4	0.28	131.0		23.0
WR-GC-31A	22-Jul-97	8.90	0.6	0.18	26.9	26.8	26.0	0.06	21.7	0.21	80.6		11.8
WR-GC-32A	22-Jul-97	10.00	3.3	0.19	28.7	31.5	22.9	0.07	22.6	0.24	99.2		13.0
WR-GC-33A	22-Jul-97	10.10	<0.5	0.29	30.4	33.0	38.7	0.09	22.8	0.33	161.0		46.0
WR-GC-34A	23-Jul-97	10.00	2.0	0.23	29.4	35.9	17.7	0.19	19.8	0.29	108.0		17.0
WR-GC-35A	23-Jul-97	10.10	<0.5	0.33	34.5	35.9	25.7	0.18	21.2	0.38	181.0		37.0
WR-BC-36	24-Jul-97	10.30	2.1	0.30	26.2	27.7	32.2	0.09	20.0	0.27	171.0	<0.05	22.0
WR-GC-37A	23-Jul-97	11.10	<0.5	0.05	13.9	11.0	3.5	0.01	10.4	0.03	37.5		<2.0
WR-GC-38A	23-Jul-97	11.20	<0.5	0.17	22.8	21.3	9.1	0.10	14.5	0.14	74.5		0.6
WR-GC-39A	23-Jul-97	11.65	2.3	0.09	17.3	15.4	5.7	0.04	12.7	0.07	190.0		0.8
WR-CD-40A	23-Jul-97	11.30	0.5	0.04	15.1	11.9	2.2	0.01	11.0	0.03	29.4		<0.7
WR-CD-41A	23-Jul-97	11.35	<0.5	0.11	22.2	17.4	26.1	0.03	17.1	0.12	80.6		2.9
WR-CD-41B	23-Jul-97	11.35	<0.5	0.06	32.7	36.4	18.5	0.09	21.0	0.34	103.0		17.9
WR-CD-42A	23-Jul-97	11.50	<0.5	0.27	35.4	30.4	26.9	0.08	23.5	0.41	102.0		11.9
WR-CD-42B	23-Jul-97	11.50	<0.5	0.19	19.0	20.9	19.9	0.08	14.2	0.25	131.0		26.0
WR-CD-42C	23-Jul-97	11.50	0.7	0.30	29.2	30.4	26.6	**0.87**	19.6	0.41	179.0		42.0
WR-CD-42D	23-Jul-97	11.50	<0.5	0.31	32.3	30.8	26.0	0.34	21.3	0.35	160.0		24.0
WR-CD-43A	23-Jul-97	11.55	19.7	2.12	17.2	70.1	**489.0**	0.03	13.8	0.12	102.0		2.9
WR-D	23-Jul-97	11.55	<0.5	0.11	19.6	18.0	64.3	0.03	14.3	0.06	55.6		42.0
WR-CD-43B	23-Jul-97	11.55	<0.5	0.07	14.4	14.4	15.0	0.10	11.9	0.05	45.9		0.9
Average Level			2.3	0.32	22.7	24.1	41.1	0.09	17.6	0.17	94.8	0.02	14.6
Maximum Level			19.7	2.12	35.4	70.1	489.0	0.87	23.7	0.41	190.0	0.42	65.0
Screening Levels			57.0	5.10	NA	390.0	450.0	0.41	140.0	6.10	410.0	0.15	

Note: The symbol "< " denotes a non-detect at the numerical level listed.

Willamette River – Pesticides/PCBs – ug/kg (ppb)

Site	Date	RM	Dieldrin	DDT	DDE	DDD	Total DDT	Chlordane	Aroclor 1242	Aroclor 1254	Aroclor 1260	Total PCBS
WR-BC-01	24-Jul-97	0.10	<2.0	<2.0	<2.0	<2.0	0.0	<10.0	<10.0	<10.0	<10.0	0.0
WR-A	24-Jul-97	0.10	<2.0	<2.0	<2.0	0.2	0.2	<10.0	<10.0	<10.0	<10.0	0.0
WR-GC-02A	24-Jul-97	0.10	<2.0	<2.0	0.7	1.0	1.7	<10.0	<10.0	<10.0	5.0	5.0
WR-GC-02B	24-Jul-97	0.10	<2.0	<2.0	<2.0	<2.0	0.0	<10.0	<10.0	<10.0	<10.0	0.0
WR-BC-03	24-Jul-97	0.40	<5.0	<2.0	0.4	0.7	1.1	<10.0	<10.0	<10.0	<10.0	0.0
WR-GC-04A	24-Jul-97	0.80	<2.0	<2.0	7.0	5.0	12.0	<10.0	29.0	43.0	<10.0	72.0
WR-GC-04B	24-Jul-97	0.80	<2.0	<2.0	4.0	7.0	11.0	<10.0	<10.0	<10.0	7.0	7.0
WR-GC-05A	24-Jul-97	0.80	<2.0	<2.0	<2.0	<2.0	0.0	<10.0	<10.0	<10.0	<10.0	0.0
WR-GC-05B	24-Jul-97	0.80	<2.0	<2.0	<2.0	<2.0	0.0	<10.0	<10.0	<10.0	<10.0	0.0
WR-GC-06A	24-Jul-97	0.95	<2.0	<2.0	<2.0	<2.0	0.0	<10.0	<10.0	<10.0	<10.0	0.0
WR-GC-06B	24-Jul-97	0.95	<2.0	<2.0	<2.0	<2.0	0.0	<10.0	<10.0	<10.0	<10.0	0.0
WR-BC-07	24-Jul-97	1.60	<2.0	<2.0	2.0	1.0	3.0	<10.0	<10.0	<10.0	7.0	7.0
WR-BC-08	24-Jul-97	1.70	<2.0	<2.0	2.0	1.0	3.0	<10.0	<10.0	<10.0	5.0	5.0
WR-BC-09	24-Jul-97	2.05	<2.0	0.3	1.0	1.0	2.3	<10.0	<10.0	<10.0	4.0	4.0
WR-BC-10	24-Jul-97	2.45	<2.0	0.3	2.0	2.0	4.3	<10.0	<10.0	<10.0	11.0	11.0
WR-B	24-Jul-97	2.45	<2.0	<2.0	2.0	2.0	4.0	<10.0	<10.0	<10.0	9.0	9.0
WR-GC-11A	24-Jul-97	2.90	<2.0	<2.0	2.0	2.0	4.0	<10.0	7.0	<10.0	21.0	28.0
WR-BC-12,13,14	24-Jul-97	3.40	<2.0	0.2	0.7	2.0	2.9	<10.0	<10.0	<10.0	5.0	5.0
WR-BC-15	24-Jul-97	3.80	<2.0	1.0	1.0	1.0	3.0	<10.0	<10.0	<10.0	9.0	9.0
WR-BC-16,17	24-Jul-97	4.10	<2.0	1.0	1.0	1.0	3.0	<10.0	<10.0	<10.0	4.0	4.0
WR-GC-18A	22-Jul-97	5.10	<2.0	0.8	2.0	2.0	4.8	<10.0	<10.0	<10.0	19.0	19.0
WR-GC-19A	22-Jul-97	5.10	<2.0	<2.0	<2.0	<2.0	0.0	<10.0	<10.0	<10.0	<10.0	0.0
WR-BC-20	24-Jul-97	5.15	<2.0	2.0	0.7	2.0	4.7	<10.0	<10.0	<10.0	4.0	4.0
WR-BC-21	24-Jul-97	5.90	<2.0	14.0	<2.0	3.3	17.3	<10.0	<10.0	<10.0	<10.0	0.0
WR-BC-22	24-Jul-97	6.20	<2.0	1.7	<2.0	<2.0	1.7	<10.0	<10.0	<10.0	<10.0	0.0
WR-BC-23	24-Jul-97	6.50	<2.0	1.7	<2.0	<2.0	1.7	<10.0	<10.0	<10.0	<10.0	0.0
WR-GC-24A	22-Jul-97	6.70	<2.0	94.0	4.0	100.0	198.0	<10.0	<10.0	<30.0	21.0	21.0
WR-GC-24B	22-Jul-97	6.70	<2.0	2.0	<2.0	0.2	2.2	<10.0	<10.0	<10.0	<10.0	0.0
WR-GC-25A	24-Jul-97	6.70	<2.0	<2.0	3.0	4.0	7.0	<10.0	26.0	<10.0	52.0	78.0
WR-BC-26,27,28	24-Jul-97	6.90	<2.0	1.9	0.7	1.3	3.9	<10.0	<10.0	<10.0	<10.0	0.0
WR-BC-29	24-Jul-97	7.50	0.4	2.1	3.0	2.4	7.5	<10.0	6.0	27.0	30.0	63.0
WR-C	24-Jul-97	7.50	<2.0	3.4	2.2	2.2	7.8	<10.0	5.0	22.0	70.0	97.0
WR-GC-30A	22-Jul-97	8.50	<2.0	0.8	1.0	1.0	2.8	<10.0	<10.0	<2.00	22.0	22.0
WR-GC-31A	22-Jul-97	8.90	<2.0	0.5	1.0	0.8	2.3	<10.0	<10.0	<10.0	9.0	9.0
WR-GC-32A	22-Jul-97	10.00	<2.0	4.0	1.0	0.7	5.7	<10.0	<10.0	<10.0	9.0	9.0
WR-GC-33A	22-Jul-97	10.10	<2.0	0.3	2.0	1.0	3.3	<10.0	<10.0	<30.0	43.0	43.0
WR-GC-34A	23-Jul-97	10.00	<2.0	<2.0	2.0	2.0	4.0	<10.0	<10.0	14.0	23.0	37.0
WR-GC-35A	23-Jul-97	10.10	0.4	<2.0	4.0	4.0	8.0	<10.0	<10.0	44.0	42.0	86.0
WR-BC-36	24-Jul-97	10.30	<2.0	0.9	2.5	1.4	4.8	<10.0	12.0	44.0	49.0	105.0
WR-GC-37A	23-Jul-97	11.10	<2.0	0.2	<2.0	0.4	0.6	<10.0	<10.0	4.0	6.0	10.0
WR-GC-38A	23-Jul-97	11.20	<2.0	<2.0	<2.0	<2.0	0.0	<10.0	<10.0	<10.0	<10.0	0.0
WR-GC-39A	23-Jul-97	11.65	<2.0	<2.0	<2.0	<2.0	0.0	<10.0	<10.0	<10.0	<10.0	0.0
WR-CD-40A	23-Jul-97	11.30	13.0	<2.0	4.0	19.0	23.0	47.0	<10.0	46.0	15.0	61.0
WR-CD-41A	23-Jul-97	11.35	<2.0	<2.0	0.5	0.4	0.9	<10.0	<10.0	6.0	6.0	12.0
WR-CD-41B	23-Jul-97	11.35	<2.0	1.0	1.0	<2.0	2.0	<10.0	<10.0	11.0	16.0	27.0
WR-CD-42A	23-Jul-97	11.50	<2.0	<2.0	1.0	0.8	1.8	<10.0	<10.0	11.0	12.0	23.0
WR-CD-42B	23-Jul-97	11.50	2.0	0.6	0.5	2.0	3.1	<10.0	<10.0	26.0	31.0	57.0
WR-CD-42C	23-Jul-97	11.50	<2.0	<2.0	2.0	0.8	2.8	<10.0	<10.0	24.0	21.0	45.0
WR-CD-42D	23-Jul-97	11.50	<2.0	<2.0	2.0	3.0	5.0	<10.0	<10.0	90.0	156.0	246.0
WR-CD-43A	23-Jul-97	11.55	<2.0	2.0	<2.0	1.0	3.0	<10.0	<10.0	<10.0	<10.0	0.0
WR-D	23-Jul-97	11.55	<2.0	<2.0	<2.0	0.3	0.3	<10.0	<10.0	<10.0	<10.0	0.0
WR-CD-43B	23-Jul-97	11.55	<2.0	<2.0	<2.0	<2.0	0.0	<10.0	<10.0	<10.0	<10.0	0.0
Average Value			0.3	2.6	1.3	3.5	7.4	0.9	1.6	7.8	14.3	0.06
Maximum Value			13.0	94.0	7.0	100.0	198.0	47.0	29.0	90.0	156.0	246.0
Screening Levels			10.0				6.9	10.0				130

Note: The symbol "< " denotes a non-detect at the numerical level listed.

Table 14, CRCD Sediment Evaluation Report

Willamette River – Low PAHs – ug/kg (ppb)

Site	Date	RM	Napthalene	2-Methyl naphthalene	Ace naphthylene	Ace naphthene	Fluorene	Phenanthrene	Anthracene	Total Low PAHs
WR-BC-01	24-Jul-97	0.10	1.0	1.0	2.0	1.0	0.7	5.0	1.0	
WR-A	24-Jul-97	0.10	1.0	2.0	1.0	0.9	1.0	4.0	1.0	10.9
WR-GC-02A	24-Jul-97	0.10	4.0	4.0	5.0	3.0	3.0	20.0	6.0	45.0
WR-GC-02B	24-Jul-97	0.10	1.0	2.0	0.7	0.9	1.0	4.0	1.0	10.6
WR-BC-03	24-Jul-97	0.40	2.0	3.0	0.5	<5.0	0.9	5.0	1.0	12.4
WR-GC-04A	24-Jul-97	0.80	31.0	27.0	11.0	16.0	19.0	96.0	27.0	227.0
WR-GC-04B	24-Jul-97	0.80	24.0	12.0	4.0	7.0	10.0	65.0	18.0	140.0
WR-GC-05A	24-Jul-97	0.80	3.0	2.0	1.0	1.0	2.0	10.0	2.0	21.0
WR-GC-05B	24-Jul-97	0.80	0.6	2.0	0.3	<5.0	0.8	3.0	<5.0	6.7
WR-GC-06A	24-Jul-97	0.95	1.0	2.0	0.6	0.7	0.7	3.0	0.6	8.6
WR-GC-06B	24-Jul-97	0.95	2.0	2.0	1.0	1.0	2.0	2.0	3.0	13.0
WR-BC-07	24-Jul-97	1.60	8.0	6.0	5.0	6.0	6.0	38.0	11.0	80.0
WR-BC-08	24-Jul-97	1.70	2.0	3.0	3.0	2.0	3.0	14.0	6.0	33.0
WR-BC-09	24-Jul-97	2.05	23.0	13.0	10.0	9.0	9.0	66.0	17.0	147.0
WR-BC-10	24-Jul-97	2.45	23.0	22.0	25.0	14.0	16.0	120.0	36.0	256.0
WR-B	24-Jul-97	2.45	19.0	21.0	14.0	11.0	14.0	105.0	29.0	213.0
WR-GC-11A	24-Jul-97	2.90	221.0	130.0	62.0	122.0	105.0	684.0	160.0	1,484.0
WR-BC-12, 13, 14	24-Jul-97	3.40	35.0	22.0	13.0	18.0	15.0	136.0	31.0	270.0
WR-BC-15	24-Jul-97	3.80	98.0	50.0	107.0	112.0	77.0	495.0	161.0	1,100.0
WR-BC-16,17	24-Jul-97	4.10	22.0	12.0	95.0	30.0	29.0	460.0	135.0	783.0
WR-GC-18A	22-Jul-97	5.10	230.0	170.0	10.0	148.0	133.0	331.0	61.0	1,083.0
WR-GC-19A	22-Jul-97	5.10	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0.0
WR-BC-20	24-Jul-97	5.15	280.0	135.0	406.0	1,700.0	940.0	8,200.0	4,400.0	16,061.0
WR-BC-21	24-Jul-97	5.90	7.0	2.0	14.0	145.0	61.0	1,900.0	189.0	2,318.0
WR-BC-22	24-Jul-97	6.20	5,300.0	1,700.0	8,500.0	79,000.0	44,000.0	180,000.0	77,000.0	395,500.0
WR-BC-23	24-Jul-97	6.50	0.5	1.0	<5.0	<5.0	<5.0	1.0	<5.0	2.5
WR-GC-24A	22-Jul-97	6.70	129.0	82.0	27.0	104.0	77.0	540.0	111.0	1,070.0
WR-GC-24B	22-Jul-97	6.70	0.6	0.6	0.2	<5.0.0	<5.0.0	<5.0.0	<5.0.0	1.4
WR-GC-25A	24-Jul-97	6.70	64.0	44.0	25.0	129.0	102.0	356.0	64.0	784.0
WR-BC-26, 27, 28	24-Jul-97	6.90	1.0	1.0	0.7	<5.0.0	0.5	4.0	0.8	8.0
WR-BC-29	24-Jul-97	7.50	22.0	69.0	4.0	8.0	9.0	50.0	13.0	175.0
WR-C	24-Jul-97	7.50	11.0	38.0	6.0	10.0	9.0	47.0	13.0	134.0
WR-GC-30A	22-Jul-97	8.50	19.0	39.0	7.0	8.0	11.0	68.0	17.0	169.0
WR-GC-31A	22-Jul-97	8.90	16.0	8.0	5.0	5.0	7.0	44.0	9.0	94.0
WR-GC-32A	22-Jul-97	10.00	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	0.0
WR-GC-33A	22-Jul-97	10.10	24.0	42.0	7.0	9.0	14.0	73.0	15.0	184.0
WR-GC-34A	23-Jul-97	10.00	55.0	24.0	66.0	21.0	13.0	124.0	42.0	345.0
WR-GC-35A	23-Jul-97	10.10	32.0	25.0	6.0	10.0	10.0	82.0	19.0	184.0
WR-BC-36	24-Jul-97	10.30	41.0	18.0	6.0	16.0	15.0	81.0	21.0	198.0
WR-GC-37A	23-Jul-97	11.10	0.5	<5.0	<5.0	<5.0	<5.0	0.9	<5.0	1.4
WR-GC-38A	23-Jul-97	11.20	9.0	3.0	8.0	19.0	8.0	88.0	23.0	158.0
WR-GC-39A	23-Jul-97	11.65	3.0	1.0	4.0	10.0	3.0	42.0	12.0	75.0
WR-CD-40A	23-Jul-97	11.30	0.4	0.6	<5.0	<5.0	<5.0	1.0	<5.0	2.0
WR-CD-41A	23-Jul-97	11.35	5.0	3.0	4.0	5.0	4.0	27.0	12.0	60.0
WR-CD-41B	23-Jul-97	11.35	26.0	15.0	14.0	59.0	41.0	226.0	52.0	433.0
WR-CD-42A	23-Jul-97	11.50	26.0	11.0	9.0	5.0	6.0	45.0	10.0	112.0
WR-CD-42B	23-Jul-97	11.50	11.0	11.0	4.0	6.0	9.0	51.0	13.0	105.0
WR-CD-42C	23-Jul-97	11.50	23.0	24.0	6.0	11.0	11.0	74.0	20.0	169.0
WR-CD-42D	23-Jul-97	11.50	44.0	22.0	7.0	14.0	15.0	90.0	19.0	211.0
WR-CD-43A	23-Jul-97	11.55	25.0	5.0	4.0	10.0	6.0	35.0	13.0	98.0
WR-D	23-Jul-97	11.55	212.0	20.0	32.0	93.0	50.0	208.0	56.0	671.0
WR-CD-43B	23-Jul-97	11.55	4.0	2.0	3.0	4.0	2.0	10.0	5.0	30.0
Average Value			137.4	54.9	183.6	1,575.1	882.1	3,752.6	1,593.4	
Maximum Value			5,300.0	1,700.0	8,500.0	79,000.0	44,000.0	180,000.0	77,000.0	395,500.0
Screening Levels			2,100.0	670.0	560.0	500.0	540.0	1,500.0	960.0	5,200.0

Note: The symbol "< " denotes a non-detect at the numerical level listed.

Table 15, CRCD Sediment Evaluation Report

Willamette River – High PAHs – ug/kg (ppb)

Site	Date	RM	Fluor anthrene	Pyrene	Benzo anthracene	Chryse ne	Benzo(b,k) fluoranthene	Benzo(a) pyrene	Ideno(1,2,3-cd) pyrene	Dibenz(a,h) anthracene	Benzo(g,h, i) perylene	Total High PAHs
WR-BC-01	24-Jul-97	0.10	10	9	4	5	14	9	8	3	9	71
WR-A	24-Jul-97	0.10	4	5	3	3	13	11	12	3	12	66
WR-GC-02A	24-Jul-97	0.10	71	96	44	52	122	103	76	13	77	654
WR-GC-02B	24-Jul-97	0.10	4	5	2	2	6	5	6	2	6	38
WR-BC-03	24-Jul-97	0.40	7	8	4	5	15	9	11	5	12	76
WR-GC-04A	24-Jul-97	0.80	158	198	86	112	160	123	108	19	115	1,079
WR-GC-04B	24-Jul-97	0.80	83	101	32	43	44	40	36	6	39	424
WR-GC-05A	24-Jul-97	0.80	10	12	3	5	7	4	5	1	5	52
WR-GC-05B	24-Jul-97	0.80	1	2	1	1	3	1	2	1	2	14
WR-GC-06A	24-Jul-97	0.95	3	5	2	2	4	2	3	1	3	25
WR-GC-06B	24-Jul-97	0.95	1	1	<5.0	1	<5.0	1	1	1	1	6
WR-BC-07	24-Jul-97	1.60	73	67	42	49	163	109	97	22	91	713
WR-BC-08	24-Jul-97	1.70	23	26	14	17	50	36	33	8	33	240
WR-BC-09	24-Jul-97	2.05	83	111	58	67	212	176	143	26	142	1,018
WR-BC-10	24-Jul-97	2.45	208	265	158	180	539	459	383	66	385	2,643
WR-B	24-Jul-97	2.45	150	172	90	105	324	251	211	39	210	1,552
WR-GC-11A	24-Jul-97	2.90	673	789	373	452	1,061	530	802	142	832	5,654
WR-BC-12, 13, 14	24-Jul-97	3.40	131	178	69	93	228	192	158	23	159	1,231
WR-BC-15	24-Jul-97	3.80	1,100	1,300	709	778	1,962	1,100	880	207	860	8,896
WR-BC-16,17	24-Jul-97	4.10	1,300	1,600	740	930	1,100	990	660	173	660	8,153
WR-GC-18A	22-Jul-97	5.10	217	215	74	90	121	81	55	11	56	920
WR-GC-19A	22-Jul-97	5.10	1	1	<5.0	<5.0	<5.0	1	<5.0	<5.0	1	3
WR-BC-20	24-Jul-97	5.15	14,000	15,000	4,200	5,400	6,600	6,200	4,500	690	4,500	61,090
WR-BC-21	24-Jul-97	5.90	2,000	2,200	97	109	113	103	74	10	78	4,784
WR-BC-22	24-Jul-97	6.20	250,000	260,000	67,000	86,000	103,000	99,000	74,000	9,100	76,000	1,024,100
WR-BC-23	24-Jul-97	6.50	1	1	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	1	2
WR-GC-24A	22-Jul-97	6.70	480	669	166	210	259	218	179	21	190	2,392
WR-GC-24B	22-Jul-97	6.70	<5.0.0	<5.0.0	<5.0.0	<5.0.0	<5.0.0	1	1	<5.0.0	1	2
WR-GC-25A	24-Jul-97	6.70	324	313	92	105	133	162	125	22	131	1,407
WR-BC-26, 27, 28	24-Jul-97	6.90	6	6	<5.0.0	3	6	3	2	1	3	30
WR-BC-29	24-Jul-97	7.50	73	73	44	49	63	41	25	7	23	398
WR-C	24-Jul-97	7.50	62	56	28	35	55	37	28	5	27	333
WR-GC-30A	22-Jul-97	8.50	96	87	46	53	68	43	35	8	34	470
WR-GC-31A	22-Jul-97	8.90	57	53	21	28	34	22	17	4	17	253
WR-GC-32A	22-Jul-97	10.00	1	1	<5.0	<5.0	<5.0	1	<5.0	<5.0	1	3
WR-GC-33A	22-Jul-97	10.10	69	81	28	42	40	25	18	5	21	329
WR-GC-34A	23-Jul-97	10.00	217	237	157	137	196	170	96	17	87	1,314
WR-GC-35A	23-Jul-97	10.10	110	104	49	54	72	42	30	7	29	497
WR-BC-36	24-Jul-97	10.30	93	93	33	40	49	33	27	7	30	405
WR-GC-37A	23-Jul-97	11.10	2	2	1	1	<5.0	1	<5.0	<5.0	1	6
WR-GC-38A	23-Jul-97	11.20	124	136	37	38	63	62	49	4	59	572
WR-GC-39A	23-Jul-97	11.65	41	48	15	16	20	20	14	3	16	193
WR-CD-40A	23-Jul-97	11.30	2	1	1	1	<5.0	1	<5.0	<5.0	1	6
WR-CD-41A	23-Jul-97	11.35	40	40	15	15	17	15	10	2	9	163
WR-CD-41B	23-Jul-97	11.35	193	160	44	45	56	44	37	6	44	629
WR-CD-42A	23-Jul-97	11.50	51	50	13	21	25	14	12	2	14	202
WR-CD-42B	23-Jul-97	11.50	61	62	23	29	35	23	17	5	18	273
WR-CD-42C	23-Jul-97	11.50	112	114	45	51	66	42	29	7	31	497
WR-CD-42D	23-Jul-97	11.50	101	93	35	39	50	34	23	5	26	406
WR-CD-43A	23-Jul-97	11.55	172	149	50	62	62	29	22	5	21	572
WR-D	23-Jul-97	11.55	310	450	135	149	183	168	116	15	121	1,647
WR-CD-43B	23-Jul-97	11.55	25	38	15	19	25	19	16	2	17	176
Average Value			5,253	5,490	1,440	1,841	2,258	2,131	1,600	206	1,640	21,859
Maximum Value			250,000	260,000	67,000	86,000	103,000	99,000	74,000	9,100	76,000	1,024,100
Screening Levels			1,700	2,600	1,300	1,400	3,200	1,600	600	230	670	12,000

Note: The symbol "< " denotes a non-detect at the numerical level listed.

Willamette River P450 RGS (Dioxin/Furan Screen)

Site	Date	RM	6 Hour B(a)P Eq (ug/g)	6 Hour TEQ (ng/g)	16 Hour B(a)P Eq (ug/g)	16 Hour TEQ (ng/g)	Ratio	Primary* Contaminates
WR-BC-01	24-Jul-97	0.10	5.7	0.3	1.4	0.1	4	both
WR-A	24-Jul-97	0.10	7.3	0.4	2.3	0.1	3	both
WR-GC-02A	24-Jul-97	0.10	8.7	0.5	5.9	0.4	1	both
WR-GC-02B	24-Jul-97	0.10	7.0	0.4	2.1	0.1	3	both
WR-BC-03	24-Jul-97	0.40	162.9	9.8	20.0	1.2	8	PAHs
WR-GC-04A	24-Jul-97	0.80	250.3	15.0	60.0	3.6	4	both
WR-GC-04B	24-Jul-97	0.80	205.2	12.3	27.3	1.6	8	PAHs
WR-GC-05A	24-Jul-97	0.80	49.7	3.0	8.6	0.5	6	PAHs
WR-GC-05B	24-Jul-97	0.80	44.0	2.6	5.6	0.3	8	PAHs
WR-GC-06A	24-Jul-97	0.95	65.6	3.9	5.3	0.3	12	PAHs
WR-GC-06B	24-Jul-97	0.95	9.6	0.6	3.3	0.2	3	both
WR-BC-07	24-Jul-97	1.60	185.9	11.2	31.1	1.9	6	PAHs
WR-BC-08	24-Jul-97	1.70	192.8	11.6	22.7	1.4	9	PAHs
WR-BC-09	24-Jul-97	2.05	166.2	10.0	28.5	1.7	6	PAHs
WR-BC-10	24-Jul-97	2.45	403.4	24.2	109.3	6.6	4	both
WR-B	24-Jul-97	2.45	192.1	11.5	101.3	6.1	2	both
WR-GC-11A	24-Jul-97	2.90	827.7	49.7	146.1	8.8	6	PAHs
WR-BC-12,13,14	24-Jul-97	3.40	198.4	11.9	37.3	2.2	5	both
WR-BC-15	24-Jul-97	3.80	155.6	9.3	41.3	2.5	4	both
WR-BC-16,17	24-Jul-97	4.10	428.4	25.7	42.6	2.6	10	PAHs
WR-GC-18A**	22-Jul-97	5.10	3.9	0.2	7.7	0.5	0.5	PCBs/Dioxins
WR-GC-19A	22-Jul-97	5.10	1.3	0.1	0.2	0.0	6	PAHs
WR-BC-20	24-Jul-97	5.15	1096.0	65.8	321.6	19.3	3	both
WR-BC-21	24-Jul-97	5.90	482.0	28.9	218.5	13.1	2	both
WR-BC-22**	24-Jul-97	6.20	814.5	48.9	1196.7	71.8	0.7	PCBs/Dioxins
WR-BC-23	24-Jul-97	6.50	8.3	0.5	0.9	0.1	9	PAHs
WR-GC-24A**	22-Jul-97	6.70	2.0	0.1	7.5	0.4	0.3	PCBs/Dioxins
WR-GC-24B	22-Jul-97	6.70	1.2	0.1	0.2	0.0	7	PAHs
WR-GC-25A	24-Jul-97	6.70	196.0	11.8	42.1	2.5	5	both
WR-BC-26,27,28	24-Jul-97	6.90	85.4	5.1	11.1	0.7	8	PAHs
WR-BC-29	24-Jul-97	7.50	326.8	19.6	64.4	3.9	5	both
WR-C	24-Jul-97	7.50	2.4	40.0	23.8	397.1	10	PAHs
WR-GC-30A**	22-Jul-97	8.50	3.0	0.2	4.7	0.3	0.6	PCBs/Dioxins
WR-GC-31A	22-Jul-97	8.90	6.4	0.4	6.7	0.4	1	both
WR-GC-32A**	22-Jul-97	10.00	3.8	0.2	6.6	0.4	0.6	PCBs/Dioxins
WR-GC-33A**	22-Jul-97	10.10	2.8	0.2	6.7	0.4	0.4	PCBs/Dioxins
WR-GC-34A	23-Jul-97	10.00	125.0	7.5	19.6	1.2	6	PAHs
WR-GC-35A	23-Jul-97	10.10	125.4	7.5	60.5	3.6	2	both
WR-BC-36	24-Jul-97	10.30	401.6	24.1	39.0	2.3	10	PAHs
WR-GC-37A	23-Jul-97	11.10	72.9	4.4	14.5	0.9	5	both
WR-GC-38A**	23-Jul-97	11.20	6.9	0.4	13.4	0.8	0.5	PCBs/Dioxins
WR-GC-39A	23-Jul-97	11.65	9.5	0.6	4.8	0.3	2	both
WR-CD-40A	23-Jul-97	11.30	9.2	0.6	8.5	0.5	1	both
WR-CD-41A	23-Jul-97	11.35	85.0	5.1	25.6	1.5	3	both
WR-CD-41B	23-Jul-97	11.35	144.7	8.7	150.9	9.1	1	both
WR-CD-42A	23-Jul-97	11.50	97.1	5.8	30.0	1.8	3	both
WR-CD-42B	23-Jul-97	11.50	116.3	7.0	30.1	1.8	4	both
WR-CD-42C	23-Jul-97	11.50	65.4	3.9	20.5	1.2	3	both
WR-CD-42D	23-Jul-97	11.50	121.0	7.3	29.4	1.8	4	both
WR-CD-43A	23-Jul-97	11.55	149.5	9.0	156.8	9.4	1	both
WR-D	23-Jul-97	11.55	141.9	8.5	46.0	2.8	3	both
WR-CD-43B	23-Jul-97	11.55	95.4	5.7	13.0	0.8	7	PAHs

Note: The term "both" indicates that PAHs and Chlorinated Compounds have been detected; if the corresponding sample analysis show PAHs & PCBs present in significant amounts, it is not likely that Dioxins are present in that sample.

*Based on ratio of 6hr/16 hr where ratio > 5 = PAHs; ratio 5 to 1 = both PAHs and chlorinated compounds; and ratio < 1 = chlorinated compounds.
ug B(a)P Eq = PAHs detected by P450 RGS.

TEQ = Chlorinated hydrocarbons detected by P450 RGS.
** See text page 8 - P-450.

Table 17, CRCD Willamette River (12 Deep Water Sites). Sampled September 14, 1998

Inorganic Metals, TOC and Organotin (TBT)

Sample I.D.	Sb	As	Cd	Cr	Cu	Pb	Hg	Ni	Ag	Zn	TOC	TBT
	mg/kg (ppm)										%	ug/L (ppb)
Grab 1	<0.02	1.8	0.27	19.5	26.2	17.7	0.07	15.8	0.2	70.1	1.98	0.05
Grab 2	0.02	1.8	0.22	17.7	22.7	13.9	0.05	16.1	0.2	66	1.38	0.05
Grab 3	<0.02	1.8	0.16	14.3	18.3	9.58	0.03	15.2	0.16	52.3	1.03	<0.02
Grab 4	0.02	1.8	0.2	21.2	26.2	17.7	0.07	16.3	0.24	67.9	2.27	<0.02
Grab 5	<0.02	1.3	0.11	9.3	13.1	5.6	0.02	12.7	0.12	40	0.81	<0.02
Grab 6	<0.02	0.7	<0.09	9.9	12.3	4.64	<0.02	12.6	0.08	38.6	0.65	0.02
Grab 7	<0.02	1.3	0.21	18.3	25.5	12.7	0.05	16.2	0.18	58.3	2.06	0.07
Grab 8	0.02	1.4	0.21	21.4	48	15.2	0.07	18.3	0.3	73.9	1.41	0.12
Grab 9	<0.15	2.4	0.14	20.1	<21.6	14.5	0.06	16.8	0.22	63.7	1.58	<0.02
Grab 10	<0.15	2	0.17	20.1	<22	14.8	0.06	17.1	0.23	63.2	1.57	<0.02
Grab 11	<0.16	2.3	0.19	22.3	<25.6	13.2	0.07	18	0.29	64.1	2.24	<0.02
Grab 12	<0.22	2.1	0.15	18.3	<20.5	13.6	0.05	16.8	0.22	63.2	1.23	<0.02
Screening level (SL)	150	57	5.1	*	390	450	0.41	140	6.1	410		0.15
Mean	0.005	1.7	0.17	17.7	16	12.8	0.05	16	0.2	60.1		0.026
Maximum	0.02	2.3	0.27	22.3	48	17.7	0.07	18.3	0.3	73.9		0.12
*SL not established												

(<) = Non-detect (ND) at method detection limit.

Pesticides/PCBs

Sample I.D.	4,4'-DDD	4,4'-DDE	4,4'-DDT	Total DDT	Total PCBs
Grab 1	<3.3	3.5	<6.7*	3.5*	13
Grab 2	<3.3	2.5	**13**	**15.9**	<10
Grab 3	<3.3	<2.3	<6.7*	<6.7	<10
Grab 4	**11**	5.9	**49**	**65.9**	13
Grab 5	**14**	<2.3	**11**	**25**	<10
Grab 6	<3.3	<2.3	<6.7*	<6.7*	<10
Grab 7	<3.3	<3.8	<6.7*	3.8*	<10
Grab 8	<3.3	2.4	<6.7*	2.4*	<10
Grab 9	<2	<2	<2	<2	<10
Grab 10	<2	<2	<2	<2	14
Grab 11	<2	3	<2	3	<10
Grab 12	<2	<2	<2	<2	14
Screening level (SL)				6.9	130

*Reporting limit exceeded screening level, value unreliable

(<) = Non-detect (ND) at method detection limit.

Table 19, CRCD Willamette River (12 Deep Water Sites) Sampled September 14, 1998

Phenols, Phthalates and Misc. Extractables

Sample I.D.	Phenols	Phthalates			Misc. Extractables		
		Di-n-octyl	Butylbenzyl	bis(2-Ethylhexyl)	Benzyl Alchol	Benzoic Acid	Dibenzofuran
	ug/kg (ppb)						
Grab 1	<20	<20	21	400	12	<100	<20
Grab 2	<20	<20	25	280	<6	<6	<20
Grab 3	<20	<20	26	200	<6	<6	<20
Grab 4	<20	<20	55	470	15	100	45
Grab 5	<3000*	<10000*	<10000*	<10000*	<50000*	<500	<10000*
Grab 6	<30	<100	<100	<100	<30	<100	<100
Grab 7	<20	<20	<100	300	6	<100	<20
Grab 8	<20	25	<20	430	9	<100	<20
Grab 9	<20	<20	38	410	<6	<100	<20
Grab 10	<20	<20	48	320	8	<100	<20
Grab 11	<20	<20	22	440	<6	<100	<20
Grab 12	<20	<20	33	1000	9	<100	<20
Screening level (SL	670	5100	970	8300	57	650	540
Mean	<20	2	22	388	5	8	4
Maximum	<30	25	55	1000	15	100	45
* Reporting limit exceeds the screening level, value unknown.							

(<) = Non-detect (ND) at method detection limit.

Table 20, CRCD Willamette River (12 Deep Water Sites)

Sampled September 14, 1998

Polynuclear Aromatic Hydrocarbons (PAHs)

Low Molecular Weight Analytes

Sample I.D.	Acenapththene	Acenaphthylene	Anthracene	Fluorene	2-Methylnapthalene	Naphthalene	Phenanthrene	Total Low PAHs
	ug/kg (ppb)							
Grab 1	<20	<20	32	<20	<20	130	162	324
Grab 2	26	21	33	<20	<20	100	180	360
Grab 3	<20	<20	25	20	<20	88	133	266
Grab 4	250	90	310	180	160	1200	2190	2190
Grab 5	**31000**	<10000*	**26000**	**14000**	<10000*	**84000**	**155000**	**310000**
Grab 6	160	<100	340	140	<100	1300	1940	3880
Grab 7	<20	<20	<20	<20	<20	23	23	46
Grab 8	<20	<20	<20	<20	<20	33	33	66
Grab 9	<20	<20	<20	<20	<20	26	26	52
Grab 10	<20	<20	<20	<20	<20	20	20	40
Grab 11	<20	<20	<20	<20	<20	48	48	96
Grab 12	<20	<20	<20	<20	<20	25	25	50
Screening level	500	560	960	540	670	2100	1500	5200
Mean	2620	9	2228	1195	13	7249	13315	
Maximum	31000	90	26000	14000	160	84000	155000	

* Reporting limit exceeds the screening level, value unknown.

(<) = Non-detect at method detection limit.

Table 21, CRCD Willamette River (12 Deep Water Sites) — Sampled September 14, 1998

Polynuclear Aromatic Hydrocarbons (PAHs)

High Molecular Weight Analytes

Sample I.D.	Benz(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(g,h,i)perylene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Indeno(1,2,3-cd)pyrene	Pyrene	Total High PAHs
Grab 1	180	230	210	150	150	190	51	350	220	330	2061
Grab 2	210	290	220	160	150	210	40	380	220	430	2310
Grab 3	81	110	89	69	72	94	<20	200	100	250	1065
Grab 4	1200	1500	1100	920	620	1200	140	**2600**	**980**	**3000**	**13260**
Grab 5	**39000**	**39000**	**19000**	**21000**	**18000**	**42000**	<10000*	**110000**	**24000**	**140000**	**452000**
Grab 6	340	340	180	190	170	360	<100	1200	230	1400	4410
Grab 7	20	22	23	<20	<20	26	<20	59	<20	62	212
Grab 8	28	29	34	26	<20	36	<20	85	23	83	344
Grab 9	26	28	29	21	<20	31	<20	67	23	68	293
Grab 10	27	36	32	24	22	32	<20	59	29	62	323
Grab 11	28	22	24	<20	<20	27	<20	85	<20	75	261
Grab 12	25	28	27	20	<20	31	<20	65	23	72	291
Screening level	1300	1600	3200		670	1400	230	1700	600	2600	12000

* Reported limit exceeds the screening level, value unknown.

(<) = Non-detect at method detection limit.

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Exhibit A

SAMPLING & ANALYSIS PLAN
FOR THE
COLUMBIA RIVER CHANNEL DEEPENING

MAY 14, 1997

Prepared by:

Portland District
Corps of Engineers

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PROJECT DESCRIPTION, SITE HISTORY AND ASSESSMENT

1.1 Project Description. The Columbia River rises in British Columbia, through which it flows for 425 miles. It enters the United States in northeastern Washington, and empties into the Pacific Ocean 645 miles north of San Francisco Bay and 160 miles south of the Strait of Juan Defuca. Total length of river is 1,210 miles and forms a boundary between the states of Washington and Oregon. The Willamette River rises in the Cascades Range in western Oregon, flows northerly, and empties into the Columbia River at Portland, Oregon about 100 miles from the sea. Its length from source of the Middle Fork is about 294 miles. Dredging is primarily concentrated in those reaches from the mouth to about RM 103.5 on the Columbia and to RM 11.1 on the Willamette along with several side channels, marinas, and docking facilities (see Appendix A for historic perspective and shoal descriptions). This sediment evaluation study only covers those sediments associated with the proposed deepening of the Federal channel to 43 feet. Sediment quality in the berthing areas or non-federal access channels of the seven deep-draft ports on the lower Columbia River that rely on the channel, including Astoria, St. Helens and Portland in Oregon, and Longview, Kalama, Woodland and Vancouver in Washington as well as all side channels will not be a part of the study area or this evaluation.

During this study sediment will be collected and subjected only to physical and chemical analyses depending on location and sediment characteristics. No biological analyses are to be conducted at this time. Depending upon the results of the feasibility study and final project design, it is expected that additional testing and evaluation will be necessary particularly along the Willamette River prior to dredging. No dredging relevant to Columbia River Channel Deepening is scheduled prior to 2003 after completion of the study and congressional authorization.

1.2 Site History. The navigation channel from the mouth of the Columbia River to Portland, Oregon was first approved in 1877. In 1882 a 30-foot entrance channel was approved. It wasn't until 1894 that the first extensive channel dredging occurred. In 1905 a 40-foot entrance channel was initiated at the mouth of the Columbia River. By 1917 the north jetty was completed and the channel stabilized below 40-foot. Fourteen million cubic yards were removed in 1956 during constructing of a 48-foot entrance channel. In 1977, 9 million cubic yards of material was removed during the construction of an authorized 52-foot entrance. The entrance channel was deepened to its present authorized depth of 55 feet between 1984 and 1986. Since 1956, approximately 160 million cubic yards of sand have been dredged from the entrance channel with an annual average of 4.1 million cubic yards. All material is removed by hopper dredge and placed at ocean disposal sites.

In 1899 the navigation channel to Portland was authorized to 25-foot (see Figure 1). This was increased to 30-foot in 1912. Construction beginning in 1914 with extensive dredging and pile dike construction. There was also extensive filling of the water front in Astoria, Oregon. The Columbia River channel was authorized to 35-foot in 1930 with construction completed in 1935. This provided the present channel configuration and established the pile dike system. The present 40-foot channel was authorized in 1962 with construction completed in 1976 (see Appendix B).

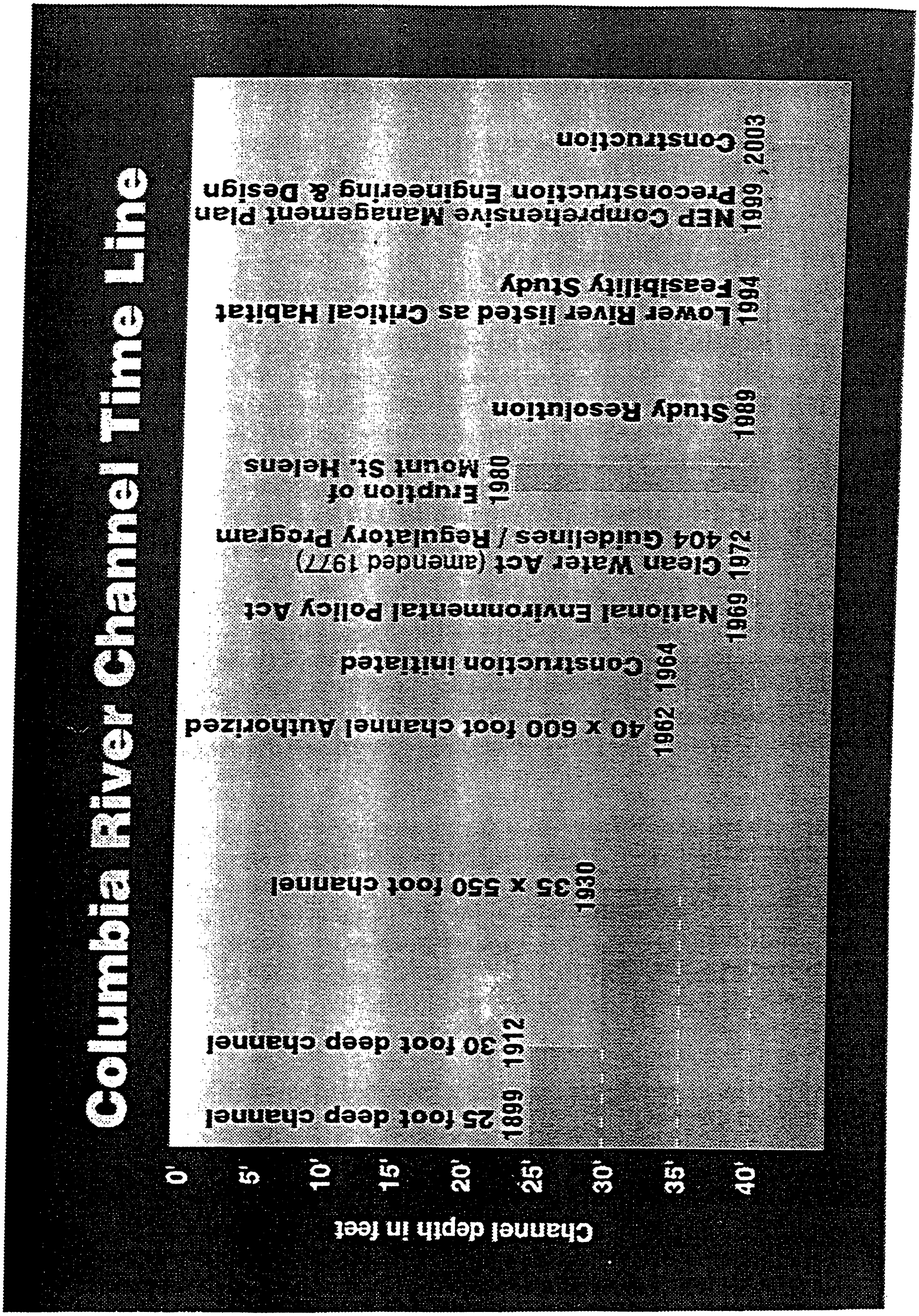


Figure 1: Columbia River Channel Time Line.

1.3 Shoaling. The vast majority of the Colombia River navigation channel shoaling is from the direct result of bedload transport. The two dominate shoal forms in the Columbia River are large sand waves and cutline shoals (see Appendix C). Sand wave shoals are present throughout the river channel and cause shoals across the channel. The main source of material for sand waves is the bed of the navigation channel. Dredging leaves a flat channel bottom on which the waves form. The wave troughs are scoured from below the dredged surface, with material from the trough then forming a wave crest. Sand wave shoals do not appear at the same location each year because of the time required for the waves to form and grow.

Cutline shoals are much larger and run parallel to the channel and develop at the same location year after year. They form along the navigation channel dredging cutline, parallel to flow, and can extend several thousand feet along the channel. Cutline shoals begin forming at the edge of the dredged cut and grow out towards the center of the navigation channel. The primary cause of the cutline shoal is gravity pulling bedload material down the side-slops and into the navigation channel.

1.4 Previous Sediment Sampling. The proposed Columbia River Channel Deepening Project consists of two distinct and different regimes with respect to sediment physical and chemical properties. The two are the lower 11.6 miles of the Willamette River and the mainstem Columbia River (see Appendix B). In the Willamette River a cutline shoal develops between RM 8.0 and 10.1 along the west side of the channel. This has been the primary location requiring maintenance dredging every 2 to 5 years. Other areas are dredged less frequently. Willamette River sediments have been subjected to chemical characterization because of the characteristics of the material dredged and close vicinity of numerous know sources of contamination (see Appendix D). While the bulk of the material evaluated from the present 40-foot channel has been found to be suitable for unconfined aquatic disposal, some material has been found to be unsuitable. The majority of the material to be dredged from the proposed channel deepening project has not been evaluated. Columbia River mainstem sediments are comprised of sand with less than 2-5% in the silt to clay size classification.

2.0 SAMPLING AND ANALYSIS OBJECTIVES

The sediment characterization program objectives and constraints are summarized below:

- To characterize sediments to confirm or establish area rankings in accordance with the draft Regional Dredge Material Testing Manual (RDMTM).
- To provide information needed to develop a baseline cost estimate relative to proper disposal of dredged material.
- To provide information for the CRCD EIS sufficient to describe the material to be potentially dredged.

- Only physical and chemical characterization will be conducted. It is anticipated that additional chemical and biological testing shall be required prior to dredging commensurate with the proposed disposal method and RDMTM.

3.0 SAMPLING AND ANALYSIS REQUIREMENTS

<u>3.1 Project Ranking.</u> Present project rankings are shown in Table 1. These initial rankings were a product of the team developing the RDMTM and were based upon existing information or lack of information (see Table 2 for rank descriptions). Higher ranks are assigned to areas known to be contaminated or which lack information and can only be downranked pending additional information. Information gathered by this study will be used to verify or modify existing ranking. Areas, particularly in the Willamette River, will be sampled which have not been previously sampled. Project ranking through this study can only be <u>verified or increased in rank,</u> no down ranking is possible as two sampling and analyses events are required to down rank an area.

Table 1: Project Area Rankings

PROJECT AREA	PROJECT	RANK				
		EXCLUSIONARY	LOW	LOW - MODERATE	MODERATE	HIGH
Main Stem Columbia	RM 5 to 20	X				
	RM 20 to 29	X				
	RM 29 to 47	X				
	RM 47 to74	X				
	RM 74 to 88		X			
	RM 88 to 99	X				
	RM 99 to 106		X			
Willamette River						
	RM 0 to 3		X			
	RM 3 to 10			X		
	RM 10 to 11.1				X	
	RM 8 to 10 O&M Shoal		X			

<u>3.2 Sampling and Analysis Requirements.</u>

Mainstem Columbia River:

The material proposed to be dredged from the mainstem of the Columbia River consist of clean sands low in fines and organic content. The areas identified consist of sand wave or cut line shoals formed by bedload transport. Material distribution in these shoals are homogeneous due to source and consistency of the hydraulic regime which form the shoals. Samples, therefore, will be collected by a modified 0.96m Gray O'Hare box corer. Based upon past sampling by the Corps and information gathered through Bi-State studies several areas have been ranked exclusionary or low. All shoals identified as requiring removal under the channel deepening project (a total of 67) will be sampled and physically analyzed for grain size and volatile solids. Some sideslope areas will also be sampled. Selected areas will also be subjected to chemical analyses. These areas have been identified by past Corps testing, the Bi-State study, or proximity to known sources as having the potential to be contaminated. It is anticipated that a total of 100 physical analyses will be conducted. Ten persecute of these will be subjected to chemical analyses.

Table 2: Ranking Guidelines

RANK	GUIDELINES	EXAMPLES
Exclusionary	Coarse grain material (greater than 80% retained on a No. 230 sieve); TVS< 5%; sufficiently removed from sources (based on historical information or BPJ).	MCR, Main Col. R. Chinook Ch.
Low	Few or no sources of chemicals of concern, data are available to verify low chemical concentrations (typically below a level predicted to result in significant biological effects) or no significant response in biological tests.	Elochoman Slough
Low-Moderate	Available data indicate a "low" rank, but there are insufficient data to confirm the ranking.	CRCD-Willamette R.
Moderate	Available data indicate chemical concentrations within a range associated historically with potential for causing adverse biological impacts. **or** Sources exist in the vicinity of the project, or there are present or historical uses of the project site, with the potential for producing chemical concentrations within a range associated historically with some potential for causing adverse biological impacts.	
High	Known chemical sources, high concentrations of chemicals of concern, or significant responses in at least one of the last two cycles of biological tests. (When a "high" rank is indicated for an area based on preliminary data, then a "high" rank is assigned to the area as a protective measure. That is, there is no rank of "high-moderate").	U.S. Moorings McCormick & Baxter

Willamette River:

Material in the Willamette River varies from medium to fine sands at the mouth to over 80% fines (silts and clays) further up the channel. Contamination of sediments in the study area range from uncontaminated to highly contaminated. There are numerous sources of contaminates ranging from combined sewer/storm water outfalls to identified superfund sites and industrial sites. In the lower sections of the river shoal areas to be removed are scattered along the sides of the proposed new cut. The depth varies from 0.0 to 3.0 feet. Above RM 7.5 shoals are typically 5.0 to 6.0 feet (the difference between the existing and proposed 43-foot channel). There are several areas however where deeper areas will have to be removed. The deepest cut will be in the proposed turning basin at RM 11.4 between the Fremont and Broadway bridge. Here on the left (west) side of the channel up to 24 feet of material will have to be removed.

Because of the variation in the depths of material that is projected to be removed different sampling equipment will have to be used. For areas where 0.0 to 3.0 feet of material will have to be removed a modified 0.96m Gray O'Hare box corer will be used. In areas with material 3.0 to 6.0 feet thick, a 3.5" Benthos gravity corer will be used. In areas greater than 6.0 feet a coring device capable of sampling the entire cut will be used. This may be a vibracorer, impact corer, or split spoon coring device depending on the equipment provided by the contractor. These longer cores will be subdivided into 6.0 foot sections for separate analyses. All samples will be subjected to physical and chemical analyses.

4.0 SAMPLE COLLECTION AND HANDLING PROCEDURES

4.1 Sampling Locations and Numbering. Figures in Appendix B show the project and sample locations. Proper QA/QC procedures as outlined in this section will be followed. Any deviation from these procedures shall be noted in the field log. Sample identification shall follow the following convention:

CR-XX-YY(Z) or WR-XX-YY(Z)

Where CR and WR denote samples collected from the Columbia River and Willamette River respectively. "XX" denotes the type of sampling device such as BC-box corer, GC-gravity corer, P-ponar; "YY" denotes the numeric sample number and will consist of two digits for all samples (i.e. 01, 09, 44, 69 etc.). For cores an alpha character (i.e. A, B, C, etc.) will to denote vertical location as represented here by "Z". The core will be divided in 6-foot sections starting from the surface until the project depth is reached or end of core. The top section will be labeled WR-XX-YYA, the next section WR-XX-YYB, and so forth to project depth. Any material retrieved from below the project depth will be sampled and labeled with the alpha character "Z". These "Z" labeled samples will be delivered to the NPD Materials Testing Laboratory with the rest of the samples for processing. The chain-of-custody form will indicate that these samples are to be held pending decisions as to possible chemical analyses.

4.2 Field Sampling Schedule. Sampling is planned for June and July 1997.

4.3 Field Notes. Field notes will be maintained during sampling and compositing operations. Included in the field notes will be the following:

- Names of the person(s) collecting and logging in the samples.
- Weather conditions.
- Depth of each station sampled as measured from the water surface. This will be accomplished using a leadline or corrected depth recorder.
- Date and time of collection of each sediment sample.
- The sample station number and individual designation numbers assigned for each individual sample.
- Descriptions of sediment or core sections.
- For cores, the length of core and the penetration depth of the sampling device.
- Any deviation from the approved sampling plan.

<u>4.4 Positioning</u>. Sampling locations will be recorded. Horizontal coordinates will be referenced to the Washington Coordinate System for proper North or South Zones NAD 27 (North American Datum 1927). Horizontal coordinates will be identified as latitude and longitude to the nearest 0.1 second.

<u>4.5 Decontamination.</u> All sampling devices and utensils will be thoroughly cleaned prior to use according to the following procedure:

- Wash with brush and Alconox soap
- Rinse with distilled water
- Rinse with 10% nitric acid solution
- Rinse with distilled water

Utensils used to collect physical samples only or sampling devices such as the box corer will be washed down before each sampling event. However, they will not require the cleaning procedure listed above as long as samples collected for chemical analyses are not in contact with the core walls. All utensils used to collect chemical samples will require decontamination prior to each use. All hand work for chemical analyses will be conducted with disposable latex gloves which will be rinsed with distilled water before and after handling each individual sample, as appropriate, to prevent sample contamination. Gloves will be disposed of between samples or composites to prevent cross contamination between samples.

<u>4.6 Core Logging</u>. Each discrete core section will be inspected and described. For each core sample, the following data will be recorded on the core log:

- Depth interval of each core section as measured from MLLW.
- Sample recovery
- Physical soil description in accordance with the Unified Soil Classification System (includes soil type, density/consistency of soil, color)
- Odor (e.g., hydrogen sulfide, petroleum products)
- Visual stratification and lenses
- Vegetation
- Debris

- Biological Activity (e.g., detritus, shells, tubes, bioturbation, live or dead organisms)
- Presence of oil sheen
- Any other distinguishing characteristics or features

4.7 Field Compositing. Some shoals may be sampled at several locations and these samples composited for one analysis. Equal aliquots of sediment will be collected from samples to be composited. When all samples for a composite have been collected and placed into the same stainless steel pan, the sample will be stirred and homogenized until a consistent color and texture is achieved.

Sufficient homogenized sample will be prepared to provide adequate volume for laboratory analyses. Physical and chemical samples will be taken from the same homogenate. Portions of each composite sample will be placed in appropriate containers. Each sample container will be clearly labeled and appropriate notations entered into the field book.

4.8 Field Replicates. Blind field replicates will be prepared and submitted along with the rest of the samples to the NPD laboratory. A total of 4 replicates for chemical analyses will be selected from sediments collected from the Willamette River. This represents about 10% of the total samples collected in the Willamette River. One sample shall represent material collected from the deep cores at RM 11 the other three will be collected from locations determined in the field from the mouth to RM 11. Sample numbers shall be WR-A, B, C, or D. Replicate sample locations shall be documented in the field log.

4.9 Sample Transport and Chain-of-Custody Procedures. After sample containers have been filled they will be packed on iced in coolers. Chain-of-custody procedures will commence in the field and will track delivery of the samples. Sample holding times and storage requirements are presented in table 3. Specific procedures are as follows:

- Samples will be packaged and shipped in accordance with U.S. Department of Transportation regulations as specified in 49 CFR 173.6 and 49 CFR 173:24 or delivered directly to the NPD materials Testing Laboratory.
- Individual sample containers will be packed to prevent breakage.
- The coolers will be clearly labeled with sufficient information (name of project, time and date container was sealed, person sealing the cooler and office name and address) to enable positive identification.
- A sealed envelope containing chain-of-custody forms will be enclosed in a plastic bag and taped to the inside lid of the cooler.

Upon transfer of sample possession to the laboratory, the chain-of-custody form will be signed by the persons transferring custody of the coolers. Upon receipt of samples at the laboratory, the coolers will be inspected and the condition of the samples will be recorded by the receiver.

Table 3. Sample Volume and Storage

Sample Type	Holding Time	Sample Size[a]	Temperature[b]	Container	Archive[c]
Particle Size	6 Months	200g	4°C	1-Liter Glass (combined)	X
Total Solids	14 Days	125g	4°C		
Total Volatile Solids	14 Days	125 g	4°C		
Total Organic Carbon	14 Days	125 g	4°C		
Metals (except Mercury)	6 Months	50 g	4°C		
Semivolatiles, Pesticides and PCBs	14 Days until extraction 1 Year until extraction 40 Days after extraction	150 g	4°C -18°C 4°C		
Mercury	28 Days	5 g	-18°C	125 ml Glass	
Volatile Organics	14 Days	100 g	4°C	2-40 ml Glass	

a. Required sample sizes for one laboratory analysis. Actual volumes to be collected have been increased to provide a margin of error and allow for retest.
b. During transport to the lab, samples will be stored on blue ice.
c. A minimum 250 ml container is filled and frozen to run any or all of the analyses indicated.
d. Containers will be completely filled with no headspace allowed.

5.0 LABORATORY PHYSICAL AND CHEMICAL SEDIMENT ANALYSIS

5.1 Laboratory Analyses Protocols. Laboratory testing procedures will be conducted in accordance with the PSDDA Evaluation Procedures Technical Appendix, June 1988; the PSDDA Phase II Management Plan Report, September 1989; and with the PSEP Recommended Protocols except as amended by this sampling plan. The samples will be analyzed for all the parameters listed in Appendix C and requested on the chain-of-custody record. Physical analysis will be conducted by the NPD Materials Testing Laboratory. All chemical analyses will be conducted by private contract analytical chemical laboratories.

5.1.1 Chain-of-Custody. A chain-of-custody record for each set of samples will be maintained throughout all sampling activities and will accompany samples and shipment to the laboratory. Information tracked by the chain-of-custody records in the laboratory include sample identification number, date and time of sample receipt, analytical parameters required, location and conditions of storage, date and time of removal from and return to storage, signature of person removing and returning the sample, reason for removing from storage, and final disposition of the sample.

5.1.2 Limits of Detection. Detection limits of all chemicals of concern must be below screening levels. All reasonable means, including additional cleanup steps and method modifications, will be used to bring all limits-of-detection below the screening levels. In addition, an aliquot of each sediment sample for analysis will be archived and preserved at -18 C for additional analysis if necessary. Sediments or extracts will be kept under proper storage conditions until the chemistry data is deemed acceptable.

5.1.3 Sediment Chemistry. All chemical analyses will be conducted by private analytical laboratories under contract with the NPD Material Testing Laboratory.

5.1.4 Sediment Conventionals. Physical parameters will be analyzed by the NPD Material Testing Laboratory. Particle grain size distribution for each sample will be determined. Sieve analysis will used a geological sieve series which will include the sieve sizes U.S. No. 5, 10, 18, 35, 60, 120, and 230. Hydrogen peroxide will not be used in preparations for grain-size analysis. Hydrometer analysis will used for particle sizes finer than the 230 mesh. Water content will be determined using ASTM D 2216. Sediment classification designation will be made in accordance with U.S. Soil Classification System, ASTM D 2487.

5.1.5 Holding Times. To the maximum extent practicable all chemical results will be provided within 28 days of receipt. All samples for physical and chemical testing will be maintained at the testing laboratory at the temperatures specified in Table 3 and analyzed within the holding times shown in the table.

5.1.6 Quality Assurance/Quality Control. The chemistry QA/QC procedures found in Table 4 will be followed.

5.2 Laboratory Written Report. A written report will be prepared by the analytical laboratory documenting all the activities associated with sample analyses. As a minimum, the following will be included in the report:

- Results of the laboratory analyses and QA/QC results.
- All protocols used during analyses.
- Chain of custody procedures, including explanation of any deviation from those identified herein.
- Any protocol deviations from the approved sampling plan.
- Location and availability of data.

As appropriate, this sampling plan may be referenced in describing protocols.

Table 4. Minimum Laboratory QA/QC

Analysis Type	Method Blank[2]	Duplicate[2]	RM[2,4]	Matrix Spikes[2]	Surrogates[7]
Semivolatiles[1]	X	X[3]	X[5]	X	X
Pesticides/PCBs[1]	X	X[3]	X[5]	X	X
Metals	X	X	X[6]	X	
Total Organic Carbon	X	X	X[6]		
Total Solids		X			
Total Volatile Solids		X			
Particle Size		X			

1. Initial calibration required before any samples are analyzed, after each major disruption of equipment, and when ongoing calibration fails to meet criteria. Ongoing calibration required at the beginning of each work shift, every 10-12 samples or every 12 hours (whichever is more frequent), and at the end of each shift.
2. Frequency of Analysis = one per batch
3. Matrix spike duplicate will be run
4. Reference Material
5. Canadian standard SRM-1
6. NIST certified reference material 2704
7. Surrogate spikes will be included with every sample, including matrix-spiked samples, blanks and reference materials

6.0 BIOLOGICAL TESTING

6.1 Biological Testing. No biological testing will be conducted under this study, however the need for biological testing will be assessed per the RDMTM.

7.0 REPORTING

7.1 QA Report. The NPD Material Testing Laboratory will prepare a quality assurance report based upon a review of the contract laboratory analytical data. The laboratory QA/QC reports will be incorporated by reference. This report will identify any laboratory activities that deviated from the approved protocols and will make a statement regarding the overall validity of the data collected.

7.2 CRCD EIS. A written discussion of findings shall be prepared documenting the physical and chemical character of potential material to be dredged as part of the CRCD EIS. The physical and chemical reports will be included as reference, individual copies will be furnished as requested. As a minimum, the following will be included in the EIS:

- Previous sampling and analyses.
- Locations where the sediment samples were collected.
- A plan view of the project showing the actual sampling location.
- Description of sampling and compositing procedures.
- Chemical testing data, with comparisons to screening levels guidelines.

APPENDIX A

HISTORIC PERSPECTIVE, MAPS, AND SHOAL DESCRIPTIONS

CURRENT MAINTENANCE DREDGING IN THE COLUMBIA RIVER

HISTORICAL PERSPECTIVE

The Columbia River rises in British Columbia, through which it flows for 425 miles. It enters the United States in northeastern Washington, and empties into the Pacific Ocean. Total length of river is 1,210 miles. The Willamette River rises in the Cascades Range in western Oregon, flows northerly, and empties into the Columbia River about 100 miles from the sea. Its length from source of the Middle Fork is about 294 miles. Dredging is primarily concentrated in those reaches from the mouth to about RM103.5 on the Columbia and to RM 11.1 on the Willamette along with several side channels, marinas, and docking facilities.

The navigation channel from the mouth of the Columbia River to Portland, Oregon was first approved in 1877. In 1882 a 30-foot entrance channel was approved. It wasn't until 1894 that the first extensive channel dredging occurred. In 1905 a 40-foot entrance channel was initiated, by 1917 the north jetty was completed and the channel stabilized below 40-foot. Fourteen million cubic yards were removed in 1956 during constructing of a 48-foot entrance channel. In 1977, 9 million cubic yards of material was removed during the construction of an authorized 52-foot entrance. The entrance channel was deepened to its present authorized depth of 55 feet between 1984 and 1986. Since 1956, approximately 160 million cubic yards of sand have been dredged from the entrance channel with an annual average of 4.1 million cubic yards. All material is removed by hopper dredge and placed at ocean disposal sites.

In 1899 the navigation channel to Portland was authorized to 25-foot. This was increased to 30-foot in 1912. Construction beginning in 1914 with extensive dredging and pile dike construction. There was also extensive filling of the water front in Astoria, Oregon. The Columbia River channel was authorized to 35-foot in 1930 with construction completed in 1935. This provided the present channel configuration and established the pile dike system. The present 40-foot channel was authorized in 1962 with construction completed in 1976.

DESCRIPTIONS OF SHOALS DREDGED

RM 3.0 to 21.4

DESDEMONA SHOAL

Project Description: The lower shoal lies between RM 5.0 and RM 8.0 extending into the channel from the Oregon side. The upper shoal lies between RM 8.7 and RM 9.4 and is on the Washington side of the channel. These shoals generally do not extend across the width of the channel.

Maintenance: The Desdemona Shoal is used as foul weather backup work for dredging equipment working at the MCR project. This is usually sufficient to keep the channel clear in this reach. There are very steep cutbacks on channel slopes. Caution in this area has been necessary to avoid either grounding hopper dredges or damaging drag arms. This area has been hopper dredged from 1986 to 1988. The maximum quantity dredged was in 1987 at 193,000 cy and the minimum dredged was 13,000 cy. The average is 84,000 cy. In FY 1992 5,104 cy of sediment was removed by hopper dredge. In FY 1994 the channel was dredged twice with a total of 74,170 cy of sediment hopper dredged and disposed at Desdemona Shoal site "D" and on the Washington side of the channel. In FY 1995 (October 1994), 236,896 cy of sediment was hopper dredged and disposed on the Washington side of the channel.

FLAVEL BAR

Project Description: This reach has sever shoaling and lies between RM 11.0 and RM 13.4. The shoaling reaches across the full width of the channel, caused by the cross-currents form Youngs Bay and the encroachment of Desdemona Sands.

Maintenance: This area is critical for commercial navigators since transit is during low tide and is required to a depth of -45 MLLW. Maintenance is primarily by hopper dredges and is often foul weather backup work for equipment working the MCR project. An annual average of 313,800 cy was dredged form the reach from 1986 to 1990. In FY 1990, 248,463 cy of sediment was hopper dredged. In FY 1991, 183,047 cy of sediment was hopper dredge. In FY 1992 the channel was dredged with both the hopper and pipeline dredges. 360,325 cy was hopper dredged while 185,565 cy was pipeline dredged, totaling 545,890 cy. In 1993 the channel was hopper dredged twice with a total of 950,609 cy of material removed. In FY May 1996, 263,126 cy of sediment was hopper dredged and was disposed at the Flavel Bar, chart 3 on the Oregon side of the channel.

UPPER SANDS

Project Description: Shoaling in this reach of the river occurs across the channel between RM 16.0 and RM 17.0.

Maintenance: Hopper dredges perform the channel maintenance; Upper Sands is often used as relief work when weather makes dredging unsafe on the MCR project. A total of 183,100 cubic yards of material was removed in 1988. Most of the material is placed at the Harrington Point Sump with some going to Site D. In FY 1993 (October and November 1992), 684,501 cy of sediment was hopper dredge and disposed at Upper Sands on the Washington side of the channel. In FY 1996 (October 1995), 60,431 cy of sediment was hopper dredge and disposed of at Harrington Point Sump.

TONGUE POINT CROSSING

Project Description: The flows in this reach disperse across Taylor Sands and trough Prairie North Channel. This dispersion tends to reduce flows in the upstream reach of this stretch of the river, inducing shoaling. The Tongue Point Crossing reach has shoaling in two locations. One shoal occurs between RM 18.7 and RM 19.1, crossing the channel from the Washington side of the cut. The other shoal, upstream at RM 20.2, is on the Oregon side of the channel.

Maintenance: Between 1986 and 1990, the annual average dredging volume was 162,400 cubic yards dredged by hopper. The Tongue Point Crossing has also been used as foul weather backup for equipment working the MCR project. The main disposal site for material is at the Harrington Sump; from there it is re-handled to Rice Island by pipeline dredges. In FY 1990, 904,300 cy was removed by clamshell and disposed at MCR site “F”. In FY 1991, the channel was hopper dredged twice and totaled 432,830 cy of material. In FY 1992, the channel was dredged three times and totaled 402,948 cy. In FY 1993, the channel was dredged three times; twice with hopper dredges that totaled 300,720 cy and once by pipeline dredge and totaled 193,621 cy. The total dredge was 494,341 cy. In FY 1994, the channel was dredged twice by hopper dredge and totaled 662,973 cy and was disposed at Miller Sands and Harrington Point Sump. In FY September 1995, 150,192 cy of sediment was hopper dredged and disposed at Harrington Point Sump. In FY June and July 1996 the channel was hopper dredged twice totaling 176,749 cy and disposed at Harrington point Sump.

Dredged Material Description for the Reach

The bulk of the material dredged from this reach consists of clean medium to fine sands. Fines and organic content are less than one percent by weight.

RM 21.4 to 29.4

MILLER SANDS CHANNEL

Project Description: There are two main shoals. The Lower Miller Sands Bar extends along the Oregon side form RM 21.4 to RM 22.5. The Upper Miller Sands Bar extends along the Oregon side form RM 23.5 to RM 24.6.

Maintenance: Hopper dredges maintain the reach intermittently form March to October, transporting material to the Harrington Point Sump disposal site. That material is later re-re-handled by pipeline dredge and placed at Miller Sands Island or Rice Island, usually during May. The majority of the reach is pipeline dredged. The average annual quantity dredged by pipeline and hopper from 1986 to 1990 was 397,200 cy and 147,200 cy respectively. In FY 1990 the channel was dredged twice by both hopper and pipeline dredges. The hopper dredged 85,536 cy while the pipeline dredge 194,741 cy, totaling 280,277 cy. In FY 1991, the channel was dredged with both a pipeline and hopper dredged. The hopper dredged 153,513 cy while the pipeline dredged 239,011, totaling 392,524 cy. Also the material was re-handled form the Harrington point Sump with a pipeline dredge that removed 468,663 cy. Also the sediment was re-handled by a pipeline dredge and removed 734,184 cy of sediment from the Harrington Point Sump. IN FY 1992, the channel was dredged three times . Twice with hopper dredges, and once with a pipeline dredge. The hopper dredges removed a total of 147,820 cy, while the pipeline dredged 436,363 cy, totaling 584,183 cy of sediments. In FY 1993, 354,268 cy was pipeline dredged. In FY 1994, 1,140,749 cy was pipeline dredged. In FY July and August 1995, 469,905 cy of sediment was pipeline dredged and disposed upland at Miller Sands on the Washington side of the channel, and was also disposed on the Oregon side for beach nourishment. In FY April, May and September 1996, the channel was hopper and pipeline dredged. 80,174 cy was hopper dredged and disposed at Harrington Point Sump and Miller Sands on the Washington side of the channel, while 236,325 cy was pipeline dredged and disposed at the Miller Sands on the Oregon side of the channel for beach nourishment. Totaled dredged was 316,499 cy.

PILLAR ROCK RANGES

Project Description: There are two shoals on the Oregon side. The main bar is the Upper Pillar Rock Bar which extends from RM 26.4 to RM 27.9. Downstream a shoal lies between RM 25 to RM 26. Shoaling is caused by side slope adjustment and erosion from Pillar Rock Island disposal areas. These ranges are a part of the LTMS study area.

Maintenance: The Pillar Rock Ranges are dredged annually by hopper and pipeline dredges. The annual average quantity for hopper from 1986 to 1990 was 196,000 cy, while the pipeline was used only in 1988. In FY 1990, 166,469 cy was hopper dredge. In FY 1992 45,107 cy was hopper dredged. In FY 1993 the channel was dredged twice by pipeline dredged, totaling 171,506 cy. In FY 1994 95,031cy of sediment was hopper dredged. In FY 1995 (March and August), the channel was dredged twice by hopper dredge, totaling 273,401 cy and was disposed at Pillar Rock Ranges on the Washington side of the channel. In FY July 1996, 35,539 cy was hopper dredged and disposed at the Harrington Point Sump.

Dredged Material Description for the Reach

The bulk of the material dredged from this reach consists of clean medium to fine sands. Fines and organic content are less than one percent by weight.

RM 29.4 to 48.4

BROOKFIELD - WELCH ISLAND REACH

Project Description: There are two shoals. The downstream shoal, the Lower Brookfield - Welch Island Bar extends form RM 29.4 to RM 30 along the Oregon edge of the channel. The upstream shoal extends from RM 31.4 to RM 32.2 along the Oregon edge of the channel on the inside bend of the river's natural channel.

Maintenance: Dredging in this area has decreased since realigning the channel 300 feet to the south and reducing the length of the pile dike by 100 feet at RM 29 on the Washington side. A pipeline dredge was used in 1986 and 1990 with an average of 287,000 cy. A hopper dredge was used in 1987 for 49,000 cy of sediment. In FY July 1990 259,395 cy was pipeline dredge and was disposed at Pillar Sands and at Brookfield on the Washington side. In FY 1993 (November 1992), 56,727 cy was hopper dredge and disposed at Miller Sands and Pillar Rock Ranges. In FY 1994, the channel was dredged by both the hopper and pipeline dredges. The hopper dredged 100,069 cy in May 1994 and the pipeline dredged 274,855 cy, totaling 374,924 cy. These we disposed at Brookfield-Welch Island. In FY June and July 1995 the channel was dredge by both the hopper and pipeline dredged. 37,699 cy of hopper dredged while 327,213 cy was pipeline dredged. These were disposed in the Brookfield-Welch Island and also on the Oregon side of the channel. In FY March, May, June, July and August 1996, 332,975 was hopper dredged and disposed at the Brookfield-Welch Island on the Washington side of the channel.

SKAMOKAWA BAR

Project Description: The Skamokawa bar reach of the navigation channel has shoaling at two locations. Welch Island Bar extends from RM 32.6 to RM 34.0 along the Oregon side of the channel. In the mid - 1980's the Oregon side was widened and the shoals have required little dredging. Skamokawa Bar lies between RM 35.0 to RM 35.9 on the Oregon side.

Maintenance: Hopper and pipeline dredges maintain these bars. The hopper dredge quantity averaged 60,000 cy in 1986 and 1987. The pipeline dredge has operated from 1986 to 1989, averaging 318,000 cy. In FY 1991 (July 1991 and October 1992) the channel was dredged by hopper and pipeline dredge. 172,969 cy was hopper dredged and disposed at the Skamokawa Bar on the Washington side of the channel. 217,859 was pipeline dredged and disposed at the Skamokawa Bar on the Oregon side of the channel. In FY July 1992 535,443 cy of sediment was pipeline dredged and disposed upland at Skamokawa Bar on the Washington side of the channel. In FY March, July and August 1994 the channel was dredged by hopper and pipeline. 260,500 cy was pipeline dredge and disposed an-water at Skamokawa Bar on the Oregon side of the channel. 29,422 cy was hopper dredged and disposed at the Skamokawa Bar on the Washington side of the channel. These totaled 289,922 cy. In FY August to September 1995, 187,916 cy was hopper dredge and was disposed in-water at the Skamokawa Bar on the Washington side of the channel. In FY 1996, (August to September 1995), 292,686 cy of sediment was removed by hopper dredged and was disposed at Skamokawa Bar.

PUGET ISLAND BAR

Project Description: There is one major shoal in this reach of the river. It lies between RM 37.4 to RM 38.7.

Maintenance; The Puget Island Bar has been dredged during 1986 to 1990, three of the five years by hopper dredge and three of five years by pipeline dredge. The five year average annual quantity for the reach is 213,800 cy. In 1990, 109,398 cy of material was pipeline dredged. In FY 1992, 151,773 cy of sediment was pipeline dredged. In 1992, 49,556 cy of sediment was hopper dredged. In FY 1993 the channel was dredged twice by hopper dredge totaling 373,228 cy. In FY 1994 210,803 cy of sediment was dredged and disposed at the Puget Island bar on the Washington side of the channel. In FY 1996 (October 1995, March and June 1996) 708,808 cy of sediment was hopper dredged and disposed at the Puget Island bar on the Washington and Oregon side in October,

WAUNA - DRISCOLL RANGES

Project Description: This range includes the Lower Westport Bar. This stretch of the river channel has three shoaling areas. Frequent dredging has been required in this area. Coffeepot Island was built as a flow control structure and has reduced the maintenance in the channel parallel to it. However, shoaling still occurs downstream of the island at Wauna Bar. Shoaling occurs at RM 43 on the Washington side near the upper end of the island. The upper segment of the Wauna - Driscoll Range is a continuance of extensive shoaling from RM 47.6 where the river separates onto two channels around Puget Island (Middle Westport Bar).

Maintenance: The Wauna - Driscoll Range has been maintained by hopper dredge, removing an annual average quantity of 211,300 cy form 1986 to 1989. Pipeline dredges have been used in 1986, 88, and 90 with an average of 299,300 cy of sediment removed. In FY 1990, 204,044 cy of sediment was pipeline dredged. In FY 1991 the channel was dredged by both the hopper and pipeline dredge. 106,257 cy was pipeline dredge and 336,221 cy was hopper dredge; totaling 442, 221 cy. In FY 1993 151,129 cy was pipeline dredged. In FY 1994 263,023 cy was hopper dredged. In FY June 1996 206,794 cy was hopper dredged and disposed at Wanua-Driscoll Ranges on the Washington side of the channel. In FY 1996 (October and November 1995), 455,901 cy was pipeline dredged and disposed on-water at Puget Island Bar on the Washington side of the channel and in several locations at the Wanua-Driscoll Ranges, both in-water and upland on the Oregon and Washington side of the channel.

WESTPORT BAR

Project Description: The Westport Bar is one of the most troublesome bars along the navigation channel. More than three miles of this segment shoals. The downstream shoal is an extension of the shoaling that occurs in the upstream segment of the Wanuna - Driscoll Range. The shoal extends from RM 44.4 to 45.4 on the Washington side. The second shoal extends from the Washington side of the channel to the Oregon side between RM 45.7 to RM 46.7. The upper Westport Bar is the most active shoal in this reach and extends from RM 46.8 upstream to RM 48.4.

Maintenance: The bars have been maintained by hopper and pipeline dredged. The average from 1986 to 1990 for the hopper dredge is 166,600 cy. The average pipeline dredge for 1986, 89, and 90 is 439,000 cy of sediment. In FY 1990, the channel was dredged by hopper and pipeline. 134, 223 cy was hopper dredged and 198,210 cy was pipeline dredge; totaling 332,433 cy. In FY 1991, the channel was dredged three times, twice by hopper dredge and once by pipeline dredge. 256,224 cy was hopper dredged, 33,720 cy was pipeline dredged; totaling 389,944 cy. In FY 1992, 284,446 cy was hopper dredged. In FY 1993 the channel was dredged four times, once with a pipeline dredged while the remaining three were hopper dredged. 693,919 cy was pipeline dredged and 285,277 was hopper dredged; totaling 979,196 cy. In FY 1994, 37,100 cy of sediment was hopper dredge. In FY August 1995, 717,747 cy was pipeline dredged and disposed in several location at the Westport Bar on the Oregon and Washington side of the channel for upland and beach nourishment . 108,584 cy of material was hopper dredged and was disposed at he Westport bar on the Oregon side of the channel. In FY 1996 (October 1995, May, June and August 1996, the channel was hopper and pipeline dredged. 88,495 cy was hopper dredged and 944,446 cy was pipeline dredged; totaling 1,032,941 cy and was disposed mostly at the Westport Bar and at the Eureka Bar all for beach nourishment.

Dredged Material Description for the Reach

The bulk of the material dredged from this reach consists of clean medium to fine sands. Fines and organic content are less than one percent by weight.

RM 48.4 to 80.3

EUREKA ISLAND

Project Description: The Eureka Bar reach experiences shoals at two locations. The Lower Eureka Bar runs from RM 49.9 to RM 50.5 on the Oregon side of the channel. The main Eureka Bar extends from RM 51.4 to RM 52.0, also predominately on the Oregon side of the channel. However, shoaling has sometimes covered the width of the entire channel for a short distance. Some natural scouring is promoted by the disposal island and pile dikes between the two shoaling areas.

Maintenance: Eureka Bar is primarily maintained by hopper dredge. Between 1986 and 1990 the project was dredged 3 of the 5 years with 73,000, 15,000 and 75,000 cubic yards dredged per year. In FY 1991 75,282 cy of material was pipeline dredged. In FY 1993 27,065 cy was hopper dredged. In FY 1994, 24,775 cy was hopper dredged and disposed at the Eureka Bar. In FY September 1996 62,019 cy was hopper dredged and was disposed at the Eureka Bar on the Washington side of the channel.

GULL ISLAND BAR

Project Description: The Gull Island reach is relatively well maintained by natural processes. One shoal exists which extends from RM 54.1 to EM 54.8 on the Oregon side.

Maintenance: The shoal has been hopper dredged from 1986 to 1990, averaging 100,400 cy annually. In 1987 the shoal was also pipeline dredged 172,000 cy of sediment. In FY 1990, 130,0505 cy was hopper dredged. In FY 1995 (November 1994), 138,488 cy was hopper dredged and disposed at the Gull Island bar on the Washington side of the channel. In FY August 1996, 59,868 cy was hopper dredged and disposed at the Gull Island Bar on the Washington side of the channel.

STELLA - FISHER BAR

Project Description: Stella Bar extends from RM 56.3 to RM 57.8 along all of the Oregon side and most of the Washington side. Flow control structures along the Oregon side hasn't reduced much of the shoaling in this reach. Fisher Bar lies between RM 58.1 and 59.4 on both the Washington and Oregon sides of the channel.

Maintenance: Pipeline dredge has been used for 1986 to 1989 while the hopper dredge was used in 1986, 1988, and 1989. The average annual quantity dredged is 297,600 cy. In 1990, the channel was dredged by hopper and pipeline dredge. 340,390 cy was hopper dredge and 553,684 cy was pipeline dredged; totaling 894,074 cy. In FY 1991 the channel was dredged three times, twice with hopper dredges and once with a pipeline dredge. 98,614 cy was hopper dredged and 229,865 was pipeline dredged; totaling 328,479 cy. In FY 1992, 445,594 cy was pipeline dredged. In FY 1993, the channel was hopper and pipeline dredged. 508,036 cy was hopper dredged and 245,919 was pipeline dredged; totaling 753,955 cy. In FY 1994, 79,597 cy was pipeline dredged. In FY march, July and August 1995, the channel was hopper and pipeline dredged. 181,982 cy was hopper dredged and disposed at the Stella-Fisher Bar on the Washington side of the channel while 103,025 cy of sediment was pipeline dredged and disposed at the Stella-Fisher Bar. These totaled 285,007 cy. In FY June and July 1996, 856,729 cy pipeline dredged and disposed at the Stella-Fisher Bar on the Washington and Oregon side of the channel for beach nourishment.

WALKER ISLAND REACH

Project Description: Walker Island Bar extends from RM 59.9 to RM 60.5 and along the Oregon side. The Lord Island Bar is a minor shoal that is located from RM 62.75 to RM 63.3 and usually forms on the Oregon side. Flow control structures has reduced the shoaling in this reach.

Maintenance: Hopper and Pipeline dredged have been used to dredge this reach. Hopper dredge has been used in 1987 and 1989 while pipeline dredge was only used in 1986. The average quantity of sediment dredged is 163, 300 cy. In FY August 1996, 51,272 cy was hopper dredged and disposed at the Walker Island Reach.

SLAUGHTERS BAR

Project Description: Areas of seasonal shoaling include a bar across the channel that develops from RM 63.6 to RM 64.37 and a shoal on the Washington side near RM 65. Sand wave shoaling develops upstream of the Lewis and Clark Bridge between Longview, WA and Rainer, OR related to sediment carried into the Columbia from the Cowlitz River.

Maintenance: The reach received heavy deposits from Mount St. Helens' eruption requiring millions of cubic yards dredged from the channel for five years following that event. By 1986, the channel had stabilized. In that year, dredging operations returned to normal maintenance levels. In 1990, 203,658 cy was hopper dredged. In FY 1991 the channel was dredged by hopper and pipeline dredge, 187,058 cy was hopper dredge and 185,600 cy was pipeline dredged; totaling 372,658 cy. In 1992, 455,194 cy was hopper dredge. In FY 1993 the channel was hopper and pipeline dredged. 283,294 cy was hopper dredge and 45,928 was pipeline dredged; totaling 329,222 cy. In FY 1994, 33,643 cy was hopper dredged. In FY 1995 (October and November 1994, June and August 1995), the channel was dredged three times, twice by hopper dredge and once pipeline dredged. 453,222 cy, was hopper dredged 372,035 cy was pipeline dredged; totaling 825,257 cy. In FY March and June 1996, 226,460 cy was hopper dredged and was disposed at Slaughters Bar and Walker Island Reach on the Oregon side of the channel.

LOWER DOBELBOWER REACH

Project Description: Shoaling is minimal in this segment of the channel.

Maintenance: Before the Mount St. Helens eruption, the Lower Dobelbower Bar required maintenance infrequently. Hopper dredges were used in 1987 and 89 while the pipeline dredge was used in 1986, 1987 and 1990. The average amount of sediment dredged is 210,600 cy. In FY 1990, the channel was dredged twice with hopper and pipeline dredges 22,008 cy was hopper dredged and 219,815 was pipeline dredged, totaling 241,823 cy. In FY 1991, 241,208 cy as pipeline dredge. In 1993, the channel was dredged by hopper and pipeline dredge. 119,047 cy was hopper dredged and 456,724 cy was pipeline dredged; totaling 575,771 cy of sediment. In 1994, 105,549 cy of sediment was removed by hopper dredge. In FY 1995 (October 1994, June and September 1995), 134,980 cy by hopper dredged and disposed at the Lower Dobelbower Bar and the Slaughter bar on the Oregon side of the channel. In FY January, February and, August 1996, was both hopper and pipeline dredged. 39,604 cy of sediment was hopper dredged and disposed at the Lower Dobelbower Bar while 176,730 cy was pipeline dredged and disposed at Slaughter Bar

UPPER DOBELBOWER BAR

Project Description: By 1987 the channel in the reach had been stabilized from the aftermath of the Mount St. Helens eruption. Over 24 million cy of sediment had been dredged from the Upper and Lower Dobelbower reaches to re-establish the channel.

Maintenance: Hopper and pipeline dredges have been used to maintain the channel. The hopper dredge was used in 1987 and 1988 while the pipeline dredge was used in 1986, 1988 and 1989. In 1988 1,016,000 cy of material was dredged by pipeline dredge. The average quantity dredged is 338,600 cy. In FY 1988 the channel was hopper ad pipeline dredged. 1,015,920 cy was pipeline dredged and 82,750 cy was hopper dredged. In FY 1989 132,632 cy of sediment was pipeline dredged. In FY 1994 132,112 cy was pipeline dredged. In FY March and September 1995, 222,476 cy hopper dredged and disposed at the Upper Dobelbower Bar on the Washington and Oregon sides.

KALAMA RANGES

Project Description: There are two shoals in this reach. The Lower Kalama Bar extends form RM 73.9 to RM 74.8 along the Oregon side. The Upper Kalama Bar shoal extends from RM 75.3 to RM 76.7 along the outer edges of Washington and Oregon sides.

Maintenance: The flow control structure at Kalama and at the upper end of the Sandy Island on the Oregon shoreline has reduced dredging. The hopper dredge was operated in 1986, 87, and 88 and the amount averaged 166,000 cy of material. The pipeline dredge was operated in 1986, 87, and 90 and averaged 235,700 cy of material. In FY 1990, 96,825 cy was pipeline dredged. In FY 1991, 296,775 cy was hopper dredged. In FY 1992, 218,361 cy was pipeline dredged. In 1993, 99,300 cy was hopper dredged. In 1994, 19,870 cy was hopper dredged and disposed at Kalama Bar on the Washington. In FY 1995 (October 1994 and September 1995), 258,949 cy was removed by hopper dredge and disposed of at the Kalama Bar on the Washington side of the channel, Lower Dobelbower Bar and Upper Dobelbower Bar on the Washington side of the channel. In FY July, June and August 1996, 219,964 cy was pipeline dredged and 180,277 cy was removed by hopper dredged; totaling 400,241 cy and was upland disposed at the Kalama Bar on the Washington side for upland disposal and on Oregon side of the channel.

Lower Martin Island Bar

Project Description: The reach near Lower Martin Island has only one area of shoaling, a bar that develops from RM 79.2 to RM 80.2 along the Oregon side of the channel. This shoal lies over a submarine crossing for a natural gas line at RM 76.75. For safety, no pipeline dredging occurs over this crossing. Hopper dredges maintain the area, holding drag arm depth to -43 feet, CRD or less.

Maintenance: Hopper dredges have maintained the bar as needed but not yearly, with average annual removal reaching approximately 246, 500 cubic yards. A pipeline dredge was used in 1989 removing 135,000 cubic yards. In 1991, 56,382 cy of sediment was hopper dredged. In FY 1992 the channel was dredged twice by hopper dredge and totaled 369,036 cy. In FY 1993, 273,34 cy was hopper dredged. In FY 1994, 111,943 cy was hopper dredged and disposed at the Lower Martin Island Bar on the Oregon side of the channel. In FY August and September 1995, 136,868 cy was hopper dredged. In FY 1995 (June, July and August 1996), 215,476 cy was hopper dredged and disposed at the Lower Martin Island Bar on the Oregon side of the channel.

Dredged Material Description for the Reach

The bulk of the material dredged from this reach consists of clean medium to fine sands. Fines and organic content are less than one percent by weight.

RM 80.3 to 106.4

UPPER MARTIN ISLAND BAR

Project Description: There are two shoals in this reach. Martin Island Bar extends form RM 80.3 to RM 81.2 on the inside turn of the Columbia River. It is continuous and shoals to depths less tan 40 feet. The upstream, and most significant, of the two shoals is the Upper Martin Island Bar which extends from RM 82.5 to RM 83.8. It is a sand wave formation resulting from bedload sediment transport and deposition.

Maintenance: Hopper dredges has maintained the channel in 1987, 1988, and 1989 and averaging 210,000 cy of material annually. In 1989, 348,000 cy of material was removed by the pipeline dredge. In FY 1992, 156,660 cy was hopper dredged. In FY 1994, 48,592 cy was hopper dredged and disposed at the Upper Martin Island Bar on the Washington side of the channel. In FY June, September 1995, 175,237 cy was hopper dredged an disposed in several locations at the Upper Martin Island Bar. In FY 1996 (October 1995, June, July and August 1996), 249,473 cy was hopper dredged and disposed at he Upper Martin Island Bar.

ST HELENS BAR

Project Description: Shoaling occurs from RM 85.0 to RM 86.6 along the Oregon channel cutline.

Maintenance: Flow control structures along the Washington shoreline has reduced maintenance dredging requirements. It is maintained as needed by hopper and pipeline dredges. In 1987 and 1988 a hopper dredge was used while in 1989 and 1990 a pipeline dredge was used. The average sediment removed with both dredges is 116,250 cy annually. In FY 1990, 193,574 cy was pipeline dredged. In FY 1994, 120,763 cy was pipeline dredged. In FY 1995, 23,758 cy was hopper dredged and disposed at the Saint Helens Bar. In FY October and August 1996, 171,564 cy was hopper dredged and disposed at the Saint Helens Bar on both the Oregon an Washington side of the channel.

WARRIOR ROCK BAR

Project Description: Two shoaling areas exist on this reach. The lower Warrior Rock is minor and extends from RM 87.7 t RM 88.0 on the Washington Side. The Upper Warrior Rock Bar extends from RM 89.6 to RM 91.4, across the full width of the channel.

Maintenance: A hopper dredge has worked in the area in each or the five years averaging removal of 206,200 cy annually. The last use of a pipeline, in 1985, removed 184, 00 cy. In FY 1990, 39,448 cy was hopper dredge. In FY 1992, 79,317 cy was hopper dredged. In FY 1993, 219,265 cy was hopper dredged. In FY 1994, 100,419 cy was hopper dredged and disposed at the Warrior Rock on the Oregon side of the channel. In FY March and September 1995, 48,325 cy was hopper dredged and disposed at the Warrior Rock on the Oregon side of the channel. In FY1996 (March, September 1995and July 1996, 104,536 cy was hopper dredged and disposed at Warrior Rock on both the Oregon and Washington side of the channel.

HENRICI BAR

Project Description: The Henrici Bar reach has two locations where shoals form and require dredging. The shoal at Henrici Bar extends form RM 90.4 upstream to RM 91.5 and is an extension of the Upper Warrior Rock Bar. The bar is created by sand wave movement, resulting in shoaling of the full width of the channel. The second shoal is at Lower Willow Bar, it is minor compared with others on the river.

Maintenance: Hopper dredges have maintained the area from 1986 to 1990, with the average removal of 205,200 cy annually. A pipeline dredge was used in 1985 removing 184,300 cy of material. In FY 1990, 35,000 cy of sediment was hopper dredged. In FY 1992 the channel was dredge twice both by hopper dredge, totaling 428,698 cy. In FY 1993 284,059 cy was removed by hopper dredge. In FY March, June July and August 1995, the channel was hopper and pipeline dredged. 144,612 cy was hopper dredged while 192,054 cy was pipeline dredged;

totaling 336,666 cy and was dispose in several locations at the Henrici bar on the Oregon and Washington sides of the channel. In FY October 1996, 9,790 cy was hopper dredged and disposed at the Henrici Bar.

WILLOW BAR

Project Description; Significant shoaling occurs in this reach. It extends from RM 95.5 to RM 97.6, occurring along both edges of the channel until the upstream end, where it extends across the width of the channel.

Maintenance: This reach has been maintained by hopper dredge from 1986 to 1990 with an average of 98,700 cy of sediment annually. A pipeline dredge was also used during 1986 and it removed 131,000 cy of sediment. In 1990, 4,800 cy was hopper dredged. In 1992, 63,106 cy was hopper dredged. In FY 1993, 17,840 cy was hopper dredged. In FY 1994 829,744 cy was hopper dredged. In FY June ad August 1995, 103,346 cy was hopper dredged. and disposed at the Willow bar on both the Oregon and Washington side of the channel. In FY June, July, October, March and June 1996, 274,646 cy was hopper dredged and was disposed at the Willow Bar on the Washington side of the channel.

Morgan Bar

Project Description: Three distinct shoals occur within the Morgan Bar reach. Furthermost downstream is an extension of the Willow Bar. The second shoal, Lower Morgan Bar, extends from RM 98.2 upstream to RM 99.0. Shoaling occurs on the Washington side as the channel attempts to migrate towards the south. Pile dikes placed at Sauvie Island and along the Oregon shoreline attempt to stabilize and control the channel. The major shoaling site in the reach extends from RM 99.3 upstream to RM 100.1. This shoal, Upper Moragn Bar, can reduce channel depth across the entire navigation channel.

Maintenance: Between 1986 and 1990 the reach was dredged three times in five years. Annual volumes were relatively constant at 20,000 to 21,000 cubic yards dredged by hopper dredge. The Oregon side of the channel from RM 100 the RM 101 is an in-water disposal area for material from Willamette River maintenance activities. In FY January 1990, 19,800 cy was hopper dredged and disposed at the Morgan Bar on the Oregon side of the channel. In FY October 1991, 21,500 cy was hopper dredged and disposed at the Morgan Dike. In FY October 1996, 29,788 cy was hopper dredged and disposed at the Morgan Bar on the Oregon side of the channel.

LOWER VANCOUVER BAR

Project Description: The potential for shoaling covers a large area in this reach, but individual shoals actually form in limited sections at any given time. Shoaling does not occur every year.

Maintenance: Dredging is infrequent. In 1987 the hopper dredge removed 7,000 cy of sediment while the pipeline dredge removed 300,000 cy of sediment. In June 1996 49,630 cy was hopper dredged on disposed at the Morgan Bar on the Oregon side of the channel.

VANCOUVER TURNING BASINS

Project Description: The authorized project provides a channel 40 feet deep and 500 feet wide from RM 101.4 to RM 104.6; a lower turning basin 40 feet deep, 800 feet wide, and 5,000 feet long; and an upper turning basin 35 feet deep, 800 feet wide, and 2,000 feet long just before the Interstate Bridge at RM 106.5.

Maintenance: The upper basin, from the railroad bridge to the Interstate 5 bridge, is maintained to a depth of 35 feet and in 1988, 303,000 cy of sediment was removed by pipeline dredge. The lower basin, downstream from the railroad bridge, is maintained to a depth of 40 feet and in 1987, 465,000 cy of sediment was removed by pipeline dredge. In 1989 5,000 cy of sediment was removed by hopper dredge but in 1990, 458,000 cy of sediment was removed. The total areas average is 307,800 cy. In 1992, 389,824 cy was pipeline dredged. In FY 1996 (November 1995), 177,657 cy was pipeline dredged and disposed upland at the Vancouver turning basin.

Dredged Material Description for the Reach

The bulk of the material dredged from this reach consists of clean medium to fine sands. Fines and organic content are less than one percent by weight.

APPENDIX B

SAMPLE LOCATIONS AND PROJECT MAPS

Columbia River Channel Deepening
Columbia River Proposed Sample Locations

Sample	Longitude	Latitude	RM	Remarks
CR-BC-1	-123:59:03.3343	46:14:01.9406	6+00	Desdemona Shoal
CR-BC-2	-123:58:40.4168	46:13:53.8876	6+18	Desdemona Shoal
CR-BC-3	-123:58:21.3699	46:13:35.9257	6+40	Off Bouy 22
CR-BC-4	-123:56:00.2036	46:12:12.4797	9+10	Flavel Bar (Chem)
CR-BC-5	-123:54:10.8466	46:11:24.0717	11+00	Flavel Bar
CR-BC-6	-123:53:15.0373	46:11:30.4439	11+40	Flavel Bar
CR-BC-7	-123:52:13.3125	46:11:32.2848	12+30	Flavel Bar
CR-BC-8	-123:51:51.6669	46:11:24.7337	12+45	Flavel Bar (Chem)
CR-BC-9	-123:49:11.7802	46:11:49.6890	15+00	Upper Sands
CR-BC-10	-123:47:34.3607	46:12:26.5769	16+25	Upper Sands
CR-BC-11	-123:45:06.0607	46:13:18.6687	18+35	Toung Pt. X-ing
CR-BC-12	-123:43:34.5881	46:13:49.2555	20+00	Toung Pt. X-ing
CR-BC-13	-123:48:56.1150	46:17:08.7026	20+50	Toung Pt. X-ing
CR-BC-14	-123:41:32.6230	46:14:51.4486	22+00	Toung Pt. X-ing
CR-BC-15	-123:39:27.5695	46:15:23.5588	23+40	Miller Sands (L side)
CR-BC-16	-123:38:17.4846	46:15:35.0619	24+40	Miller Sands
CR-BC-17	-123:35:14.5464	46:15:22.4087	27+10	Piller Rock
CR-BC-18	-123:33:31.3486	46:15:26.9171	28+30	Piller Rock
CR-BC-19	-123:32:02.0550	46:15:40.1670	29+40	Piller Rock
CR-BC-20	-123:29:16.2230	46:16:18.7428	32+05	Brooksfiel-Welch (L side)
CR-BC-21	-123:27:58.5393	46:16:05.1881	33+10	Skamokawa Bar (L side)
CR-BC-22	-123:26:17.2022	46:14:49.5667	33+10	ditto (L of Ctr., Chem)
CR-BC-23	-123:25:29.3459	46:12:33.2189	38+00	Puget Is. Bar
CR-BC-24	-123:25:38.0984	46:11:41.0153	39+00	Puget Is. Bar (R side, Chem)
CR-BC-25	-123:24:58.0377	46:10:15.4260	40+45	Wanna-Driscoll(L Ctr,Chem)
CR-BC-26	-123:23:14.5903	46:09:02.2613	42+40	ditto (L of Ctr., Chem)
CR-BC-27	-123:21:36.4559	46:08:41.7907	44+10	Wanna-Driscoll
CR-BC-28	-123:20:36.9378	46:08:32.5597	45+00	Wanna-Driscoll
CR-BC-29	-123:19:21.2834	46:08:32.0508	46+00	West Port Bar
CR-BC-30	-123:17:51.5459	46:08:37.8018	47+10	West port Bar
CR-BC-31	-123:16:52.1139	46:08:48.6908	48+00	West port Bar
CR-BC-32	-123:13:12.8288	46:10:14.6658	51+20	West port Bar
CR-BC-33	-123:09:35.6055	46:11:20.3455	54+30	Island Bar (L side)
CR-BC-34	-123:07:17.7356	46:11:07.9353	56+20	Stella-Fisher Bar (L side)
CR-BC-35	-123:06:15.6285	46:10:43.4611	57+20	ditto (R side, Chem)
CR-BC-36	-123:05:18.2519	46:10:09.7332	58+20	Stella-Fisher Bar
CR-BC-37	-123:11:29.7216	46:13:28.9081	59+10	Stella-Fisher Bar
CR-BC-38	-123:03:10.7658	46:09:15.3678	60+20	Walker Is. (L side)
CR-BC-39	-123:01:30.0908	46:08:26.9657	62+00	Walker Is.
CR-BC-40	-123:00:12.3010	46:07:58.3243	63+10	Slaughters Bar (Chem)
CR-BC-41	-122:59:29.9738	46:07:27.0209	64+00	Slaughters Bar Chem)

CR-BC-42	-122:58:38.1992	46:06:48.7298	65+00	Slaughters Bar
CR-BC-43	-122:57:52.6910	46:06:25.0230	65+40	Slaughters Bar
CR-BC-44	-122:57:20.4945	46:06:19.3331	66+10	R Turning Basin Lower
CR-BC-45	-122:56:30.9667	46:06:01.3646	66+50	R Turning Basin Upper
CR-BC-46	-122:56:09.8545	46:05:50.3446	67+15	L Dobelbower Bar (R side)
CR-BC-47	-122:53:00.0084	46:03:51.2050	70+45	U Dobelbower Bar
CR-BC-48	-122:52:46.5037	46:03:01.3898	71+45	U Dobelbower Bar
CR-BC-49	-122:52:17.2524	46:01:43.0832	73+25	U Dobelbower Bar (R side)
CR-BC-50	-122:51:07.9427	46:00:43.8057	74+50	Kalama (R of Ctr.)
CR-BC-51	-122:50:47.3695	45:59:53.3304	75+50	Kalama (R of Ctr.)
CR-BC-52	-122:50:21.3255	45:59:04.7564	76+50	@E8 on BiState (Chem)
CR-BC-53	-122:48:36.9406	45:57:26.6275	79+20	L Martin Is. Bar (L side)
CR-BC-54	-122:48:17.0262	45:56:23.2216	80+35	U Martin Is. Bar (L side)
CR-BC-55	-122:48:25.1414	45:55:07.9420	82+08	U Martin Is. Bar (Chem)
CR-BC-56	-122:48:25.0157	45:54:23.5578	83+00	U Martin Is. Bar (Chem)
CR-BC-57	-122:48:82.-----	45:54:32.------		@E9D on BiState (Chem)
CR-BC-58	-122:47:54.8348	45:53:04.4499	84+31	Jct w/ St. Helens Ch (Chem)
CR-BC-59	-122:47:25.0667	45:52:29.2106	85+20	St Helens Bar (L side, Chem)
CR-BC-60	-122:47:10.1016	45:52:07.1731	85+45	St Helens Bar (L side)
CR-BC-61	-122:47:04.2865	45:51:21.7615	86+40	ditto (L sideslope, Cem)
CR-BC-62	-122:47:15.7772	45:50:19.6795	88+00	Warrier Rock Bar
CR-BC-63	-122:47:35.6691	45:49:30.0103	89+00	Warrier Rock Bar (R side)
CR-BC-64	-122:47:33.9660	45:48:40.4233	90+00	Henrici Bar (R side)
CR-BC-65	-122:47:05.5824	45:47:53.7864	91+00	Henrici Bar
CR-BC-66	-122:46:28.2783	45:47:08.5875	92+00	Henrici Bar (L of Ctr.)
CR-BC-67	-122:45:51.3934	45:46:25.2233	93+00	Henrici Bar
CR-BC-68	-122:45:34.4431	45:45:36.7177	93+50	Henrici Bar (R of Ctr.)
CR-BC-69	-122:45:33.6004	45:44:42.5466	95+00	Henrici Bar
CR-BC-70	-122:45:36.7032	45:43:51.4174	96+00	Henrici Bar
CR-BC-71	-122:45:54.2874	45:43:00.7651	97+00	Willow Bar
CR-BC-72	-122:46:11.6581	45:42:10.0429	98+00	Willow Bar
CR-BC-73	-122:46:20.5107	45:41:00.6805	99+20	Morgan Bar (R of Ctr, Chem)
CR-BC-74	-122:46:27.7855	45:41:00.0435	99+20	Morgan Bar (Ctr. Ch, Chem)
CR-BC-75	-122:46:31.9109	45:40:59.6139	99+20	Morgan Bar (L side, Chem)
CR-BC-76	-122:46:07.9882	45:40:09.1738	100+20	Morgan Bar (R of Ctr)
CR-BC-77	-122:46:03.8366	45:39:47.0415	100+45	Morgan Bar (L side)
CR-BC-78	-122:45:35.0403	45:39:22.6433	101+25	Morgan Bar (R side)
CR-BC-79	-122:44:39.0406	45:38:50.7520	102+25	L Vancouver (R side)
CR-BC-80	-122:43:45.1358	45:38:37.8835	103+12	L Vancouver (R side, Chem)
CR-BC-81	-122:43:03.0185	45:38:27.3920	103+45	L Vancouver (R side)
CR-BC-82	-122:43:04.5671	45:38:25.2145	103+45	L Vancouver (Ctr. Channel)
CR-BC-83	-122:43:05.7394	45:38:23.1613	103+45	L Vancouver (L side)
CR-BC-84	-122:42:40.6247	45:38:19.6836	104+10	U Vancouver (R side, Chem Copper spill)
CR-BC-85	-122:42:16.1175	45:38:09.6405	104+10	U Vancouver (R side, Chem

				Copper spill)
CR-BC-86	-122:41:24.1493	45:37:38.6678	105+25	Downsteram RR Brdg(Chem)
CR-BC-87	-122:41:07.3576	45:37:29.9672	105+40	Upstream RR Brdg
CR-BC-88	-122:40:28.6568	45:37:16.7597	106+20	Downstream of I-205 Brdg (R of Ctr., Chem)
CR-BC-89	-122:40:32.7099	45:37:11.1850	106+20	Downstream of I-205 (L of Ctr)

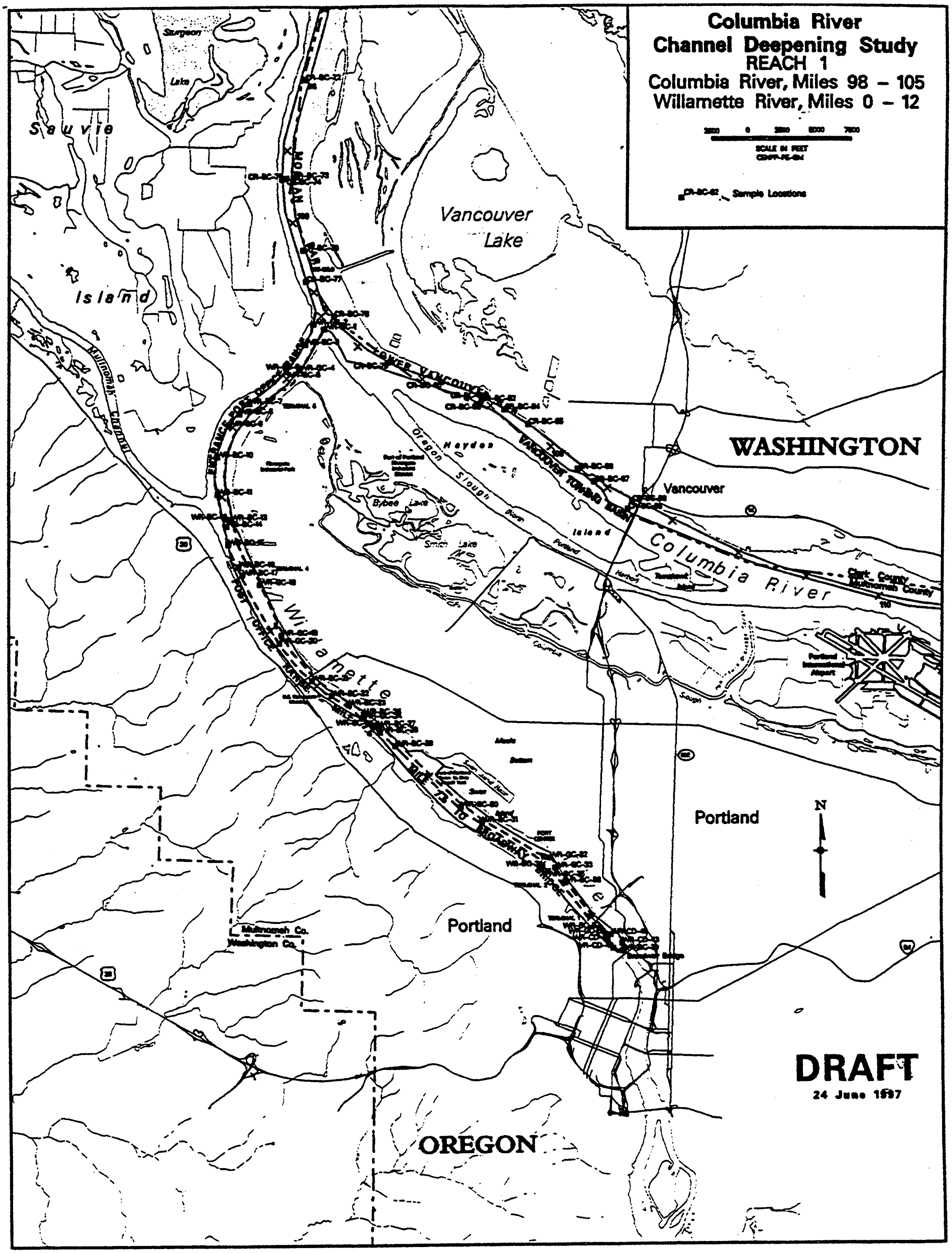
Columbia River Channel Deepening — 20-Jun-97

Willamette River Sampling Locations — US Army Corps of Engineers

Portland District

Sample	Longitude	Latitude	RM	Remarks
WR-BC-1	-122:45:44.3362	45:39:13.3370	0.1	Rt Mouth (Box Core)
WR-GC-2	-122:45:54.9805	45:39:16.5667	0.1	Lt Mouth (Gravity Core)
WR-BC-3	-122:46:02:3906	45:39:02.1708	0.4	Lt
WR-GC-5	-122:46:08.0703	45:38:44.7709	0.8	Rt D/S Term 5 (-4 w/-5)
WR-GC-4	-122:46:06.7203	45:38:43.8529	0.8	Lt D/S Term 5 (-5 w/-4)
WR-GC-6	-122:46:20.7350	45:38:42.8349	0.95	~ mid-channel
WR-BC-7	-122:46:57.3869	45:38:19.4082	1.6	"
WR-BC-8	-122:47:06.8303	45:38:12.1734	1.7	"
WR-BC-9	-122:47:16.6692	45:38:03.4129	2.05	"
WR-BC-10	-122:47:28.2057	45:37:41.3380	2.45	"
WR-BC-11	-122:47:26.2800	45:37:15.0665	2.9	"
WR-BC-12	-122:47:17.0763	45:36:57.6300	3.4	Rt D/S Term 4; Composite
WR-BC-13	-122:47:11.6621	45:36:57.1153	3.4	Lt of C/L; Composite-12,-14
WR-BC-14	-122:47:16.5328	45:36:52.2947	3.5	Lt of C/L; Composite-12,-14
WR-BC-15	-122:47:14.0216	45:36:39.3717	3.8	Rt of C/L
WR-BC-16	-122:47:02.7247	45:36:23.8457	4.1	~ C/L; Composite-16,-17
WR-BC-17	-122:46:58.8536	45:36:18.1072	4.4	~C/L ; Composite -16,-17
WR-GC-18	-122:46:41.0228	45:36:11.5496	5.1	Rt of C/L
WR-GC-19	-122:46:17.4757	45:35:35.8326	5.1	Rt of C/L
WR-GC-20	-122:46:19.2367	45:35:30.2858	5.15	L/t of C/L

Sample	Longitude	Latitude	RM	Remarks
WR-BC-21	-122:45:45.1441	45:35:04.2830	5.9	Lt D/S Moorings
WR-BC-22	-122:45:25.4092	45:34:53.8719	6.2	Lt D/S Moorings
WR-BC-23	-122:45:08.0541	45:34:47.6289	6.5	~ mid-channel
WR-GC-24	-122:44:52.1496	45:34:38.5182	6.7	Rt D/S RR Br
WR-BC-25	-122:44:52.4081	45:34:41.5870	6.7	Lt D/S RR Br
WR-BC-26	-122:44:43.0783	45:34:33.8529	6.9	Lt U/S RR Br; Comp-26,-28
WR-BC-27	-122:44:37.7302	45:34:33.4267	7.0	Rt U/S RR Br, Comp-26, -28
WR-BC-28	-122:44:35.0715	45:34:29.1617	7.1	~ mid-channel, Comp-26,-28
WR-BC-29	-122:44:19.6199	45:34:19.7144	7.5	~mid channel
WR-BC-30	-122:43:12.1918	45:33:37.2890	8.5	Swan Is
WR-BC-31	-122:42:50.2430	45:33:26.9055	8.9	Swan Is
WR-GC-32	-122:41:40.8248	45:33:02.8328	10.0	Rt D/S Turning Basin
WR-GC-33	-122:41:35.4903	45:32:55.6554	10.1	Rt U/S Turning Basin
WR-BC-34	-122:41:48.2905	45:32:56.4872	10.0	Lt D/S Turning Basin
WR-BC-35	-122:41:42.6042	45:32:52.9740	10.1	Lt U/s Turning Basin
WR-BC-36	-122:41:26.2867	45:32:45.0068	10.3	~mid-channel
WR-BC-37	-122:40:49.2764	45:32:13.2822	11.1	Lt of C/L
WR-GC-38	-122:40:43.1427	45:32:09.5219	11.2	C/L D/S Turning Basin
WR-BC-39	-122:40:25.7998	45:31:57.7696	11.65	C/L U/S Turning Basin
WR-CD-41	-122:40:40.4862	45:32:04.8735	11.35	Lt D/S Trn Bsn (Core Drill)
WR-CD-42	-122:40:35.1566	45:31:59.3912	11.5	Lt U/S Turning Basin
WR-CD-43	-122:40:26.1315	45:32:03.1942	11.55	Rt U/S Turning Basin
WR-CD-40	-122:40:37.7078	45:32:08.9439	11.3	Rt D/S Turning Basin



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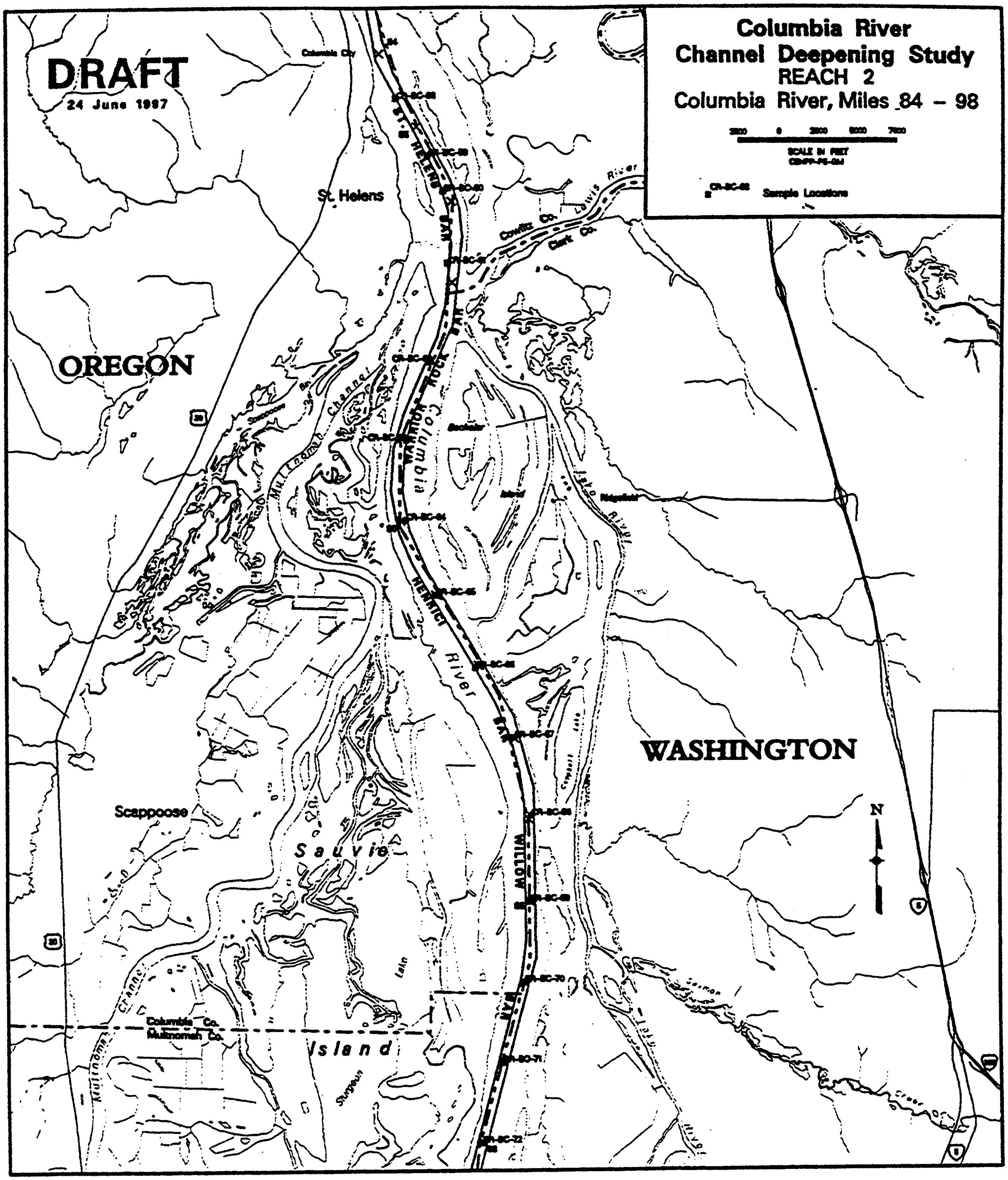

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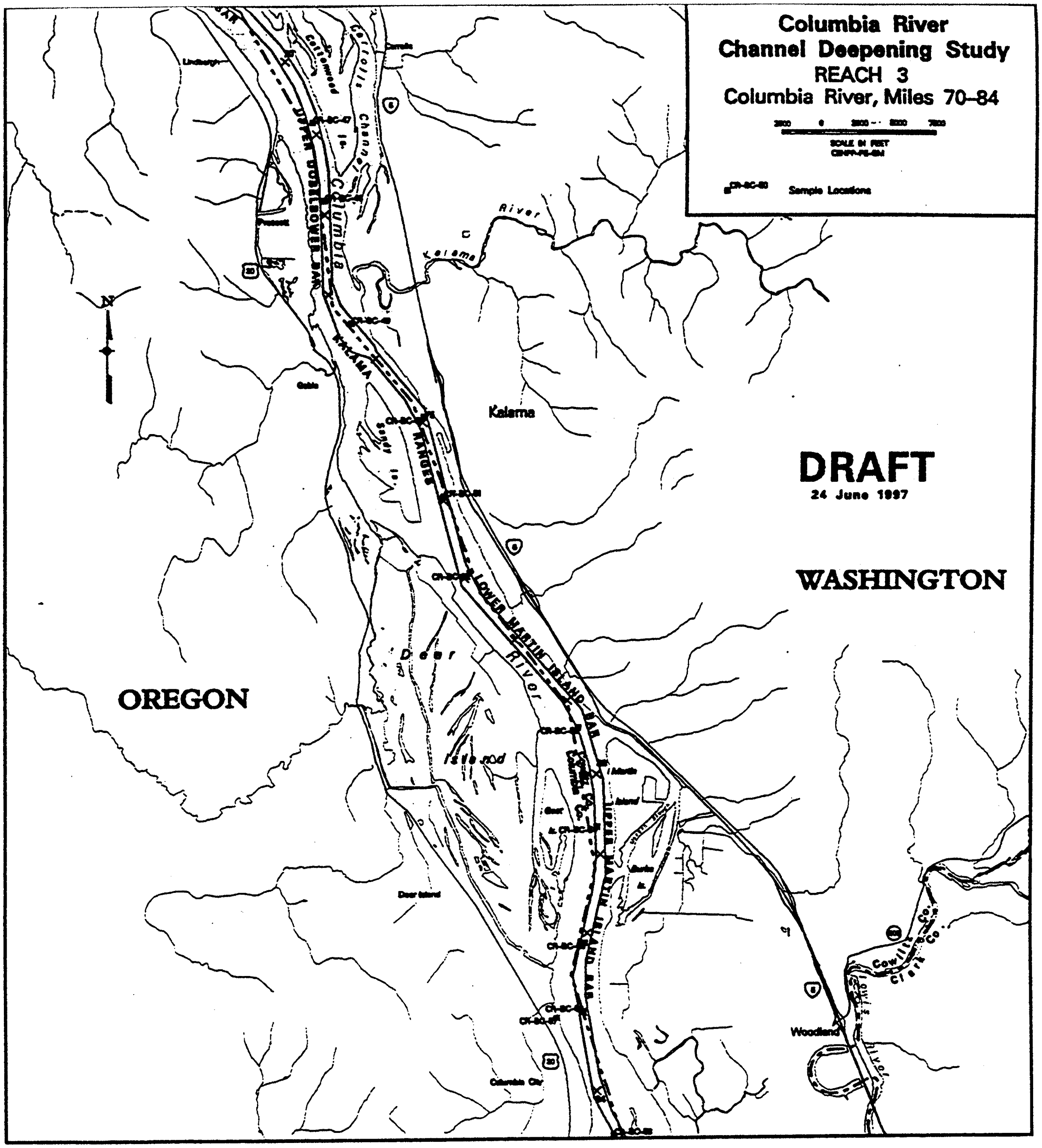

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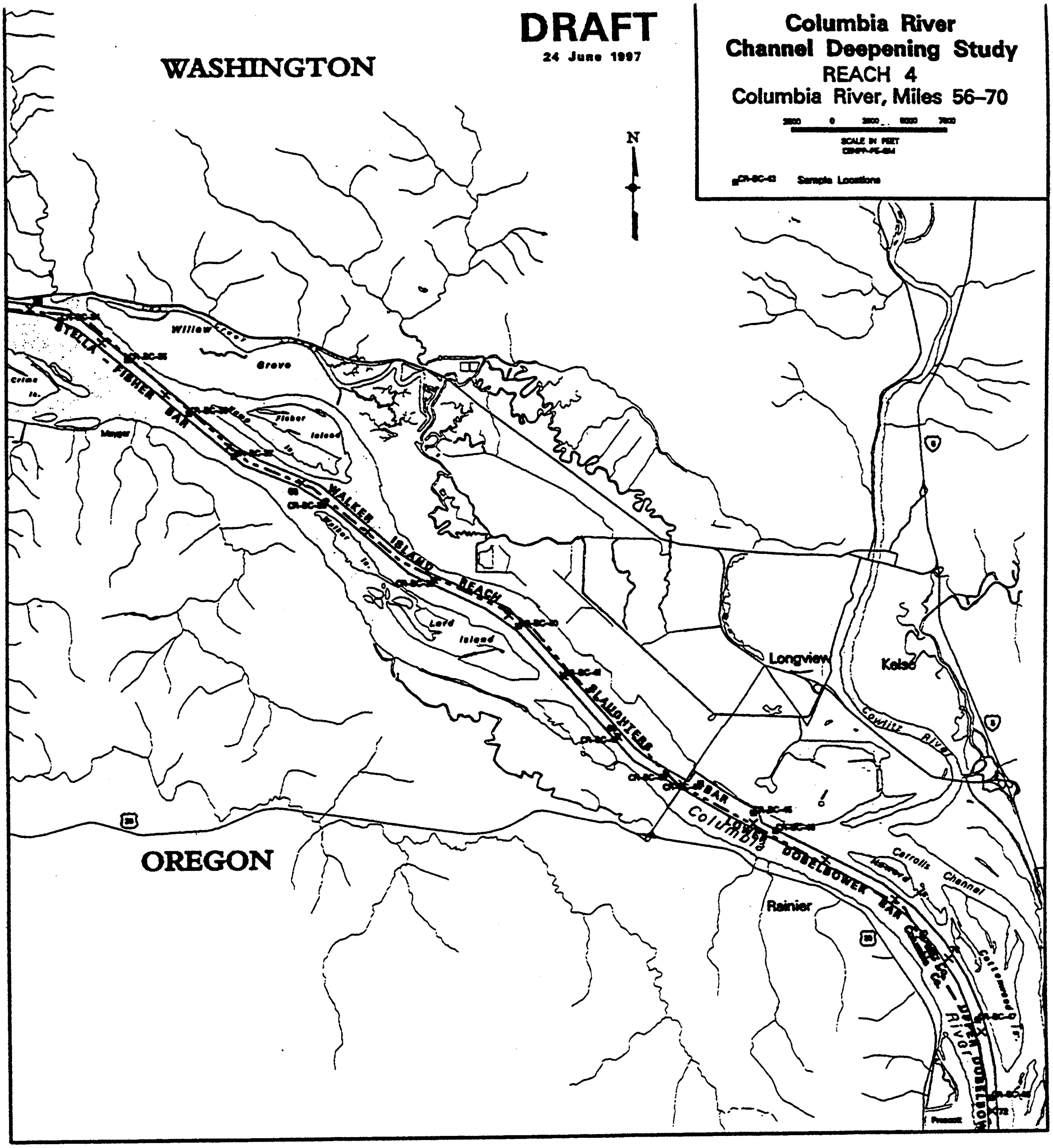

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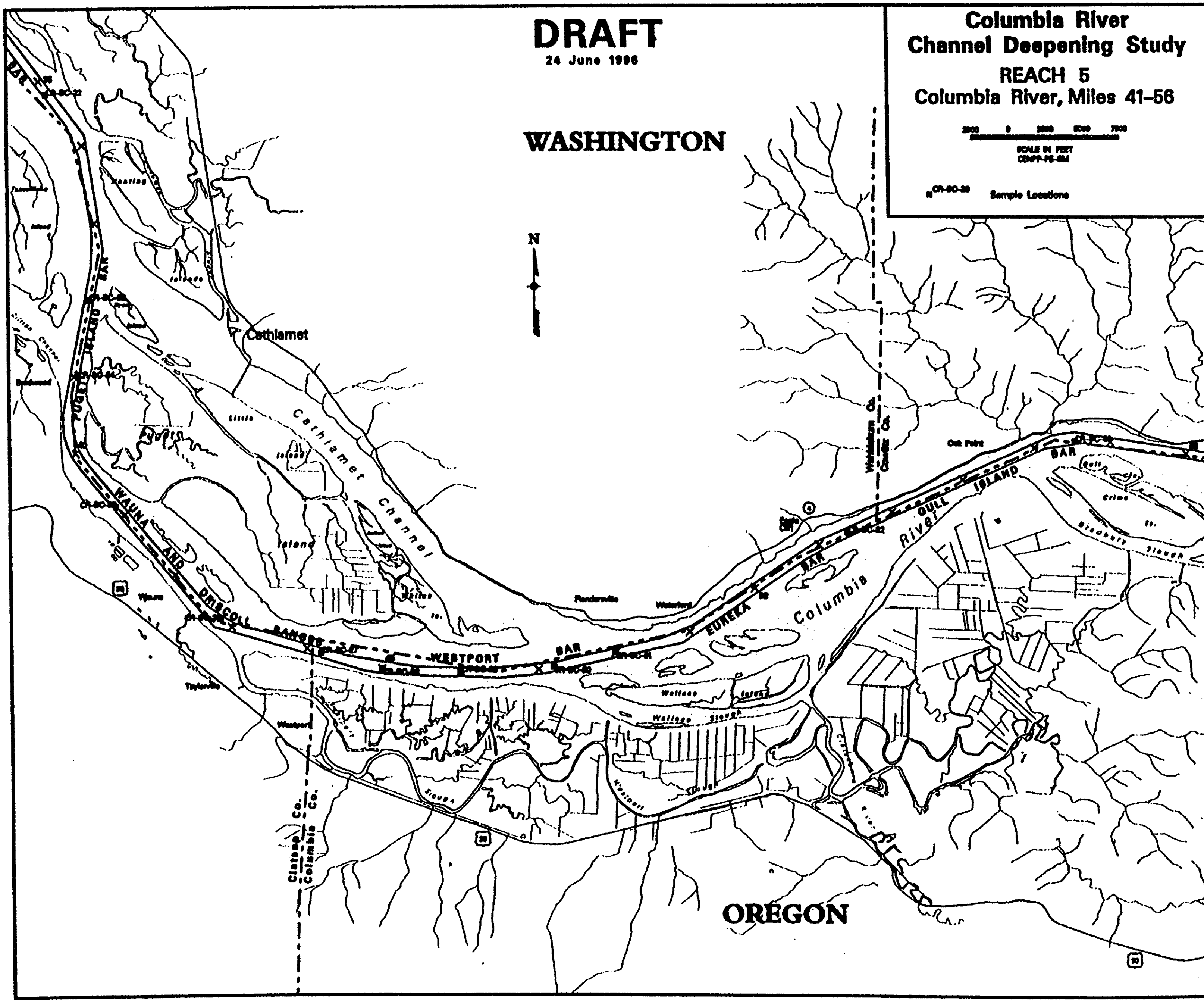

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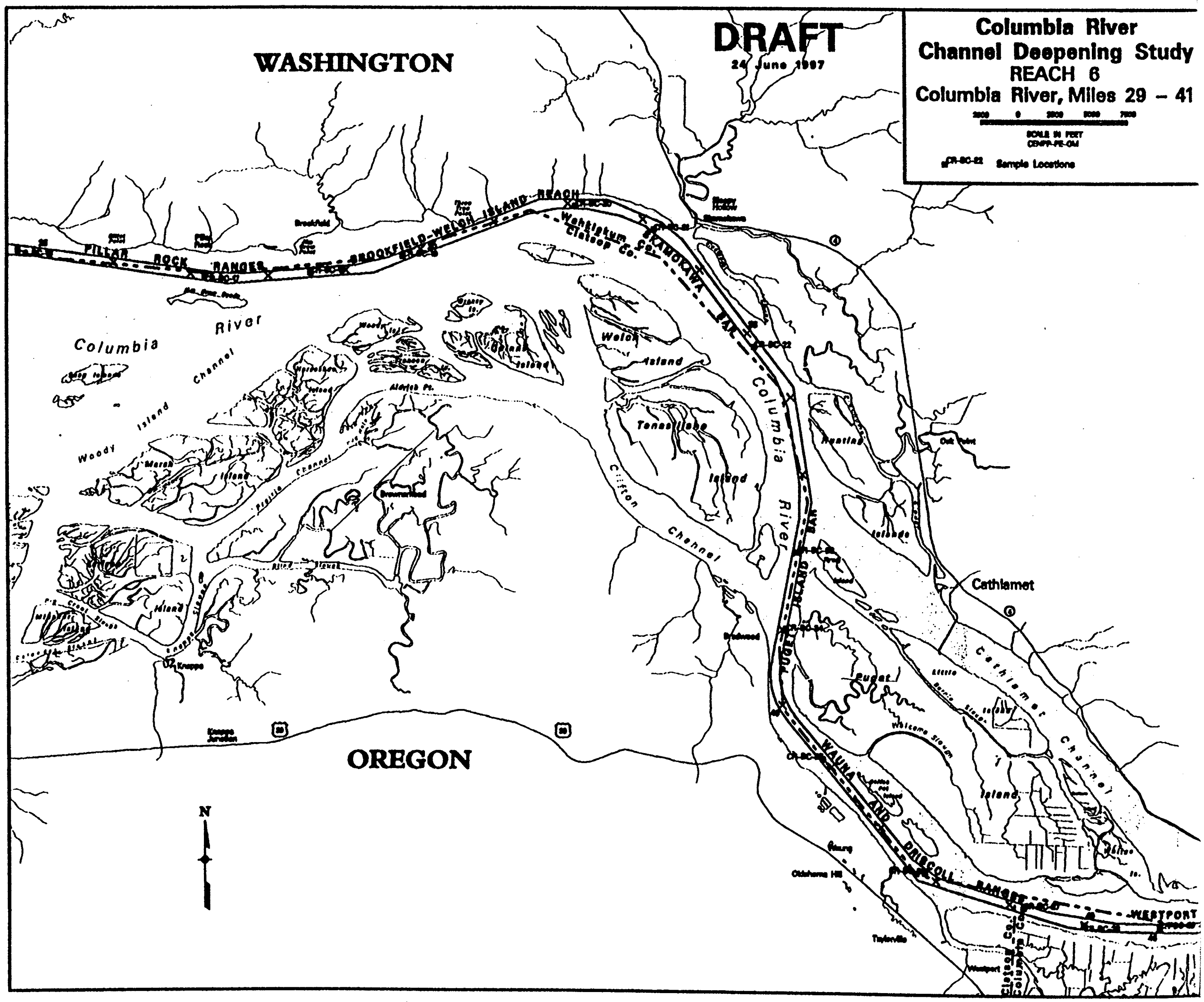

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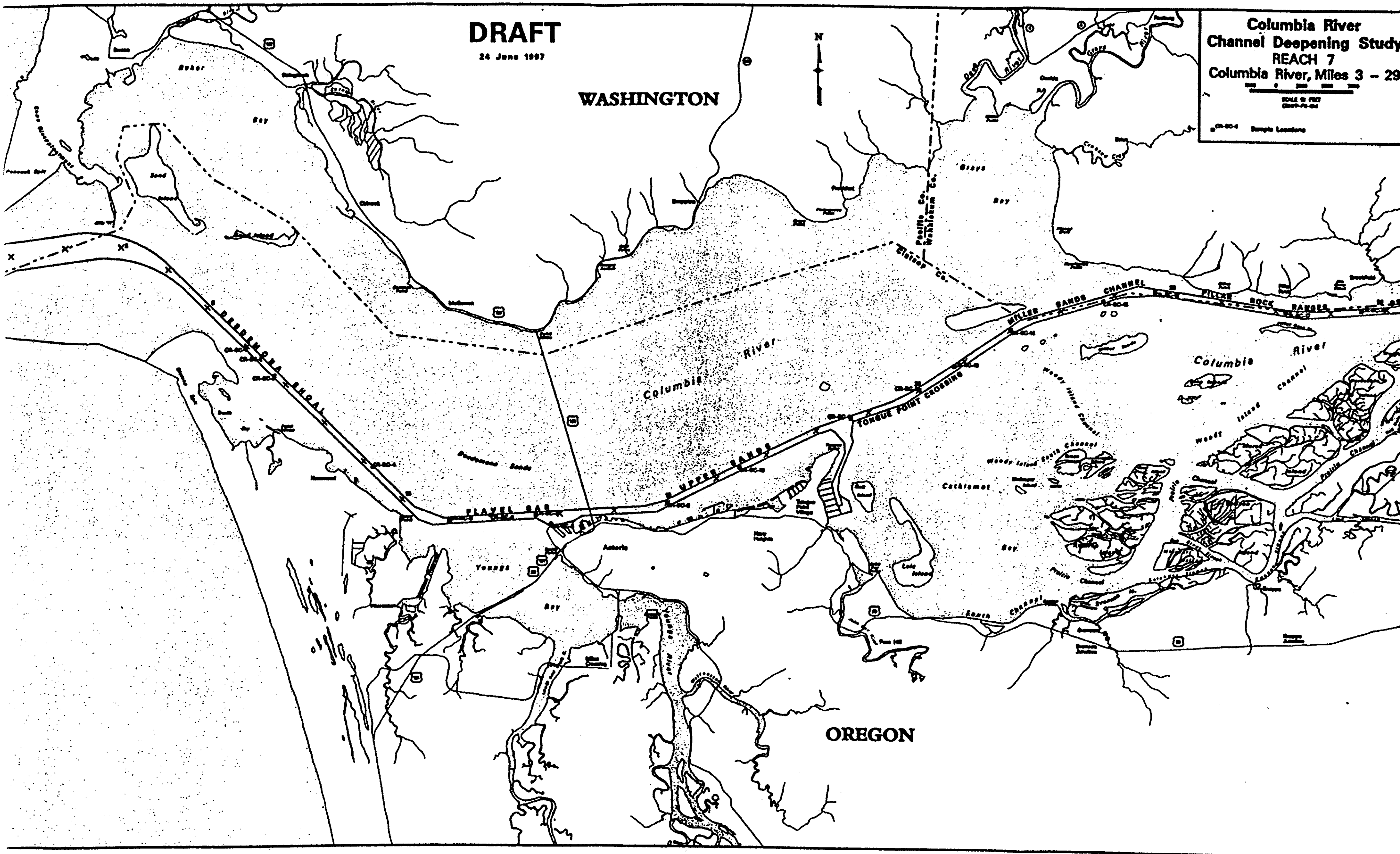

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APPENDIX C

HYDRAULICS AND SEDIMENTATION REPORT

(Appendix A from Nov. 1990 Columbia River
Channel Deepening Reconnaissance Report)

COLUMBIA RIVER

NAVIGATION CHANNEL DEEPENING STUDY

HYDRAULICS AND SEDIMENTATION REPORT

RECONNAISSANCE REPORT

APPENDIX A

Prepared By

U.S. Army Engineer District, Portland

November 1990

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COLUMBIA RIVER NAVIGATION CHANNEL DEEPENING STUDY
HYDRAULICS AND SEDIMENTATION REPORT

EXECUTIVE SUMMARY

This report presents the results of the hydraulic and sedimentation analyses done for the Columbia River navigation channel deepening study. The main emphasis of this report is a forecast of the future operation and maintenance (O&M) dredging for the proposed 42- and 45-ft navigation channels. Those channels follow the same alignment and use the same amount of advance maintenance dredging as the existing 40-ft channel. The 42-ft channel between RM 3 and RM 48 would initially add about 600,000 cy/yr to the existing O&M dredging. The 45-ft channel from RM 3 to RM 107 would initially increase O&M dredging by over 3.5 mcy/yr. Included in the new projects are improvements in dredged material disposal which will gradually reduce O&M requirements for the project. The O&M quantities return to current levels in about 20 years. The improved disposal practices will require some changes in the type of dredge used to maintain certain bars, but relies mainly on the same equipment currently used in the Columbia River.

The hydraulic impacts of the 42- and 45-ft channels are expected to be minor. Due to the wide variation in existing channel hydraulics, the changes in velocities and water surface elevations will generally fall within the normal range of river conditions. Deepening the channel will result in increased riverbed erosion near the dredging locations, leading to the increase in O&M dredging. As sediment is removed from the river by dredging there will be an increase in the average river depth and increased shoreline erosion. Shoreline erosion will mainly occur along the sandy beaches created by past disposal operations.

INTRODUCTION

Purpose.

This report documents the hydraulic and sedimentation analyses performed for the Columbia River Navigation Channel Deepening Study. The emphases of this work has been on forecasting future operation and maintenance (O&M) dredging, and evaluating the potential hydraulic and sedimentation impacts. The alternatives considered were a 42-ft channel between river miles (RM) 3 and 48, and a 45-ft channel from RM 3 to RM 107. To provide a measure of the expected changes with a new project, descriptions are given of existing river conditions, current O&M practices and potential improved O&M practices for the 40-ft channel.

Methods.

The methods used in this study are in accordance with EC 1110-2-265, Engineering and Design for Civil Works Projects, dated 1 September 1989 and EM 1110-2-1613, Hydraulic Design of Deep-Draft Navigation Projects, dated 8 April 1983. The hydraulic and sedimentation analyses relied on historic dredging and bathymetric data dating back to the 1890's and on recent studies of O&M practices and river behavior between RM's 3 and 53. Knowledge of dredging and river processes gained during the Lower Columbia River Maintenance Improvement Review (MIR) (USACE Portland, 1988) and the Long-Term Management Strategy for Dredged Material Disposal in the Columbia River Estuary (LTMS) (USACE Portland, 1990) was particularly useful and was extrapolated to the remainder of the study area.

Limitations.

The major limitations of this study are related to the intent of the reconnaissance phase of the planning process to only determine if there is a Federal interest in a proposed project. Only two alternatives (42-ft between RM's 3 and 48, and 45-ft between RM's 3 and 107) were evaluated in the study and no attempt was made to optimize those alternatives. For purposes of this analysis, the "with-project" channel alignment, width, and O&M dredging practices were kept the same as those of the current 40-ft channel. The safety and navigability of the proposed alternatives for ships larger than those of the current Columbia River fleet could not be addressed because a "design vessel" was not identified.

A decision was made at the beginning of the study that dredged material disposal would be upland or ocean where possible, and that in-water and shoreline disposal would only be used where favorable conditions existed. The selected disposal plan differs from current practices, but is expected to be more economical and simplified the O&M dredging analysis.

Construction of new river control structures, suitability of the Columbia River entrance channel for deeper draft ships, and possible changes in advance maintenance dredging (AMD) practices were not included in this reconnaissance study. While control structures have the potential to significantly reduce long-term O&M dredging requirements, there was not sufficient time or money to evaluate them during the reconnaissance phase. The entrance channel may require deepening to transit deeper ships without delays, but since it is a separate project from the river channel it was not included in this study. AMD practices effect both the initial construction volume and the long-term O&M dredging, but again were not evaluated because of the time and funding limitations.

DESCRIPTION OF STUDY AREA

Morphology.

The Columbia River deep-draft navigation channel extends from the mouth to the Portland, Oregon/Vancouver, Washington area, about River Mile (RM) 107. The area covered by this study is that portion of the Columbia River channel between RM's 3 and 107 and the Willamette River from RM 0 to RM 11. The Columbia River reach was divided into an estuarine reach downstream of RM 25 and riverine reach upstream of that point. The general planform of the study area is shown in Figure 1.

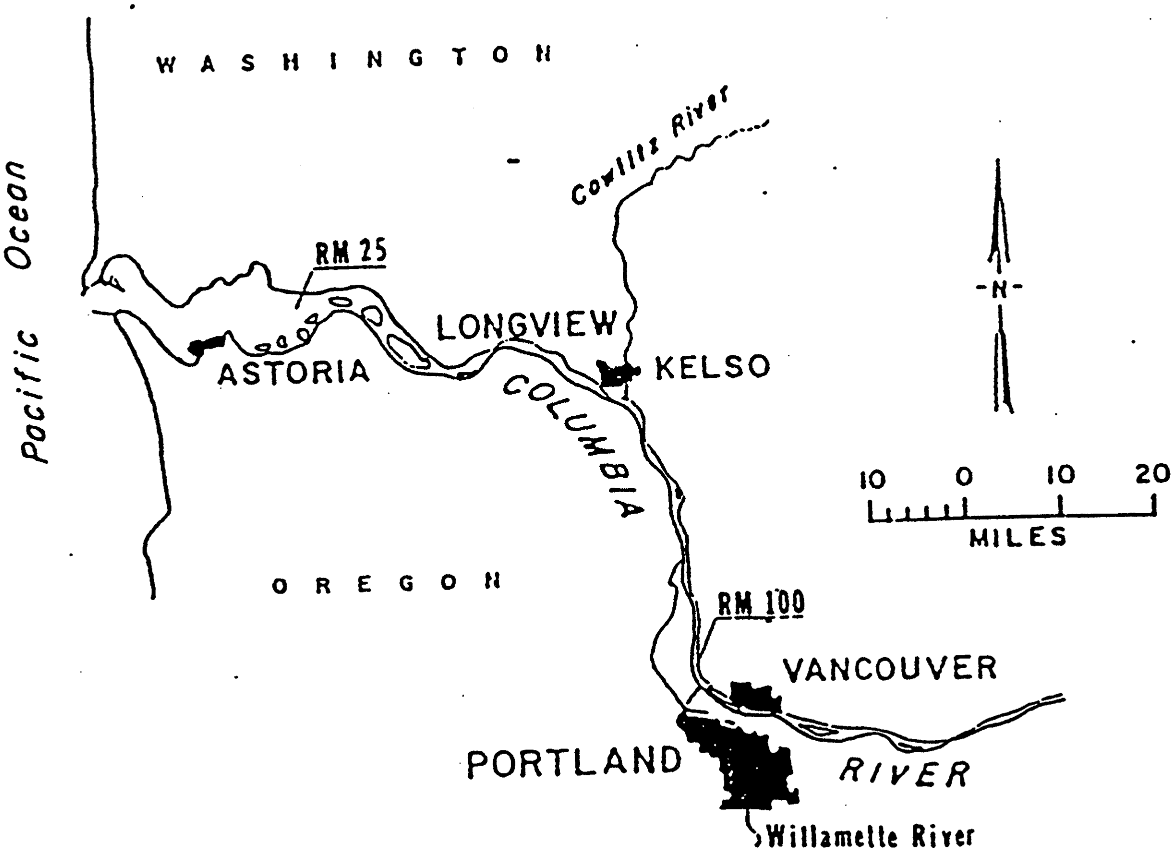

Figure 1. Study Area Map.

Estuarine Reach. The Columbia River estuary is 4-5 miles wide and extends upstream to around RM 25. It contains two main channels, the North and South channels. The South Channel is an extension of the main river channel upstream of the estuary and carries most of the upland river discharge. The navigation channel follows the South Channel through the estuary. The North Channel extends upstream to about RM 20, near Gray's Bay. These two deep channels are separated by wide, shallow inter-tidal and sub-tidal flats.

Riverine Reach. Upstream of RM 25, the main Columbia River channel generally varies from 1700 ft to 3000 ft wide, with minor bifurcations. Portions of the river have been constricted by pile dikes and sand fills in efforts to improve navigation channel maintenance. The amount of constriction varies from a few hundred feet to several thousand feet. The river bends tend to have very long radii, typically over 15,000 ft. Sharper bends only occur where basalt cliffs control the river's alignment, such as near RM's 32, 40, and 54. The bed of the main channel is composed of deep deposits of mostly fine and medium sand (0.125-0.50 mm). Silt and clay make up less than 5 percent of the main channel's bed material. The natural riverbanks consist of basalt or erosion resistant silt and clay deposits. These overbank silt-clay deposits range from 20 ft to 150 ft thick and overlay much deeper sand deposits. Sandy beaches occur only where dredged material has been placed along the shore. There has been little change in the river's location in the last 6,000 years (USACE, 1986).

Navigation development has had an impact on main channel depths as well on widths. Current thalweg depths are generally near 50 ft throughout most of the study area. This is only slightly deeper than prior to navigation development when much of the main river channel had natural thalweg depths in the 35 ft to 45 ft range. However, the controlling depth (minimum depth available anywhere along the navigation channel) has increased from about 12 ft prior to development, to 40 ft for the present channel. Typically, depths across the entire channel have also increased in reaches with large hydraulic control structures or high dredging rates. Channel areas with depths of over 50 ft occur mainly on the outside of bends and around rock outcroppings.

Navigation Channel Development.

The Columbia River navigation project was originally authorized in 1878 with a 20-ft minimum depth. The navigation depth was increased to 25-ft in 1899. In 1912, the project authorization was changed to 30-ft deep by 300-ft wide and construction was completed in 1920. Between 1930 and 1935, the navigation channel was again enlarged, this time to 35-ft deep by 500-ft wide. The current 40-ft deep by 600-ft wide channel was authorized in 1962 and completed in 1976. Beginning with the 20-ft channel in the 1880's, the design depth has been achieved and maintained through a combination of dredging and hydraulic control works.

Dredging has been required to construct and maintain each stage of channel development. The annual dredging volumes to construct and maintain the navigation channel since 1906 are shown in Figure 2. Prior to 1912 and construction of the 30-ft channel, dredging was limited to a few very shallow reaches of the river, where the natural controlling depths were in the 12-15 ft range. From 1912 to 1935, dredging became necessary along most of the channel and the annual volumes reflect a combination of almost continuous channel development and O&M activities. During this time, the channel was deepened twice (at some locations new depths were constructed in one operation and at other locations it was done in stages), widened to 500 ft, much of the channel was realigned, and many hydraulic control structures were built. Dredging was especially high between 1930 and 1935, during construction of the 35-ft by 500-ft channel. The period from 1936 to 1957 was one of primarily O&M dredging, except for some continuing channel alignment adjustments that added to the dredging requirements. During the 1936 to 1957 period, dredging averaged 6.7 mcy/yr. By 1958, the channel alignment had generally stabilized, but, O&M dredging was augmented to increase the depth of advance maintenance dredging (AMD) from 2 ft to 5 ft to allow the channel to shoal for a year and still provide full project dimensions (USACE Portland, 1961). The current 40-ft by 600-ft channel was constructed in stages between 1964 and 1975. Since 1976, O&M dredging has averaged approximately 6.5 mcy/yr, after making adjustments for emergency dredging related to the eruption of Mount St. Helens in 1980.

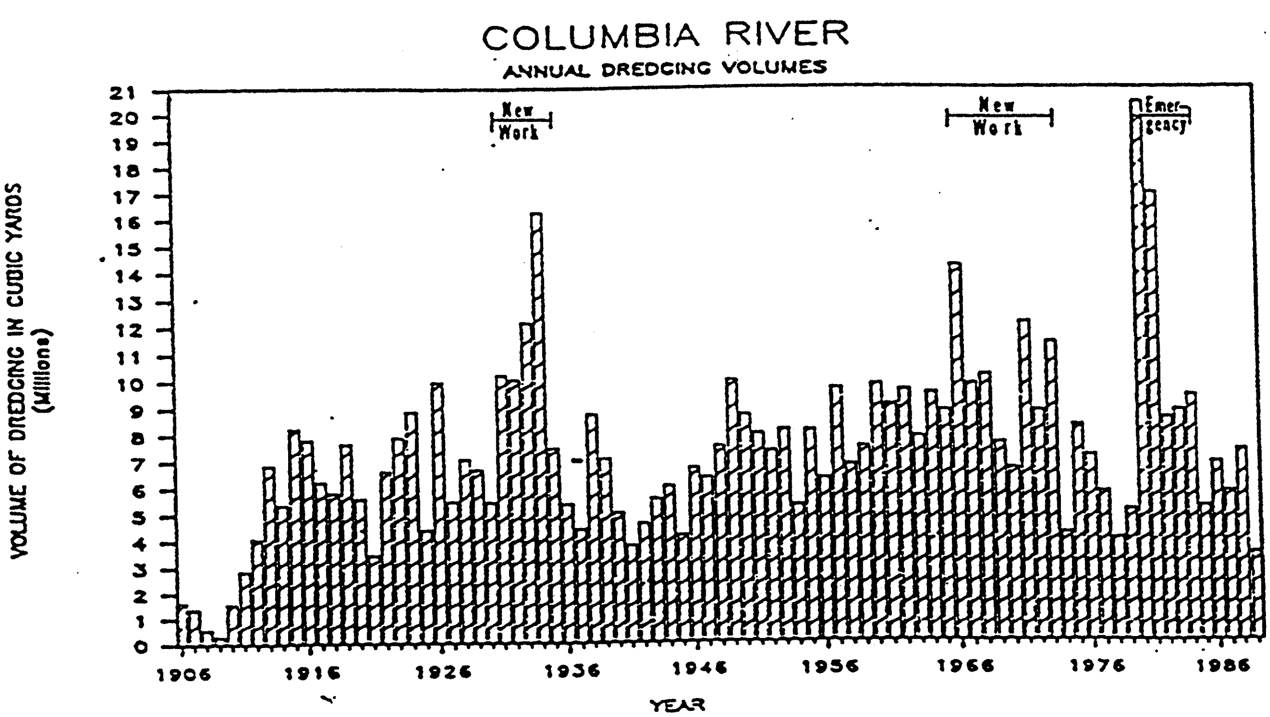

Figure 2. Historic Columbia River Dredging Volumes.

Pile dikes are a common hydraulic control measure in the river. They have been used to improve channel alignment for navigation, reduce cross-sectional area, restrict flow in back-channels, and provide bank protection. The Corps initiated pile dike construction in 1885, but the bulk of the pile dike system was built between 1917 and 1939. The last significant additions to the pile dikes system were built during construction of the 40-ft channel in the 1960's to further constrict flow and reduce erosion at dredged material disposal sites. The Corps currently maintains a total of 236 pile dikes within the study area.

Sand fills, constructed with dredged material, have also been used extensively to reduce channel cross-section and control channel alignment. Most fill has been placed along the shoreline to constrict flow. Upstream of RM 20, nearly half the shoreline along the main channel is composed of dredged material fill. Dredged material has also been used to create several islands to control channel alignment, such as Coffeepot, Lord, Sandy, Goat, and Sand islands. Pile dike fields protect most of these dredged material fill sites from erosion.

A long period of riverbed adjustment has followed each step in navigation channel development. The amount of dredging required to maintain the navigation channel during these adjustment periods has depended on the magnitude of the disturbance to the pre-existing riverbed. The development actions have included channel deepening, constrictions, realignments, and fills. The channel deepenings may be viewed as low intensity disturbances that impacted large areas and significantly increase O&M dredging. Many of the constrictions, realignments, and fills have caused high intensity, local area disturbances that also caused significant increases in O&M dredging. Because of the frequency and variation of channel development activities, there is no simple correlation between channel depth and O&M dredging requirements. Future O&M dredging will depend on the magnitude of the overall disturbance to the riverbed.

The current navigation channel is maintained to minimum dimensions of 40-ft deep and 600-ft wide. It generally follows the river's thalweg and most of the channel is deeper than the required 40 ft. Shoals tend to form in reaches of the channel where the depths prior to construction were less than 40 ft. Hopper and pipeline dredges annually remove about 6.5 mcy of sand from the shoals in the navigation channel. Material from hopper dredges is disposed of in deep water outside the navigation channel. The most common practices for pipeline dredges are upland and shoreline disposal. Occasionally, a pipeline will end-dump material in-water alongside the channel.

Hydrology.

The Columbia River drains 259,000 sq mi, originating in Canada's Columbia Lake and flowing 1,214 mi to the Pacific Ocean. The average annual discharge at the mouth is over 210,000 cfs. Flow from the upper Columbia River is dominated by snowmelt, causing low winter flows and spring freshets. Heavy winter rainfall in the lower basin can cause winter freshets to occur in the study area. Reservoirs upstream of the study area, store water during the spring snowmelt. After completion of the large Canadian storage reservoirs in the early 1970's, the 2-yr flood peak at The Dalles, OR., was reduced from 580,000 cfs under natural conditions to 360,000 cfs with regulation (USACE North Pacific, 1987). Flows in the study area would be slightly higher due to local inflows. Low flows, typically in the 100,000 cfs range, occur in September and October, after the snowmelt runoff but before the winter rains. Stored water is released during the fall low flow period to increase hydro-electric power generation.

Hydraulics.

Ocean tides produce complex, unsteady flow conditions in the lower 140 miles of the Columbia River. The mean tide range is nearly 8 ft at the mouth and about 2.5 ft at Vancouver. Because of this tide range, instantaneous discharges can range from negative values (upstream flow) during the flood tide, to twice the mean daily value at peak ebb flow. The tidal effects are much greater during low river flows than during high flows.

The estuary has two deep-water channels, one on the north side and one on the south side. The North Channel extends upstream to Grays Bay (about RM 20), but is only connected to the main river channel by shallow cross estuary channels and tidal flats. The North Channel is, in general, a slightly flood dominant channel. The South Channel is the main river and navigation channel. The South Channel is heavily ebb dominant, giving the estuary a net clockwise circulation pattern.

Between RM's 20 and 30, the main channel shifts to the north side and numerous shallow channels flow through Cathlamet Bay on the south. Upstream of RM 30, the river has a single main channel, with occasional side channels around islands. In the main channel, typical peak ebb velocities are in the 3 fps range, with freshet velocities over 6 fps. During extreme low flows, flow reversals can occur as far upstream as RM 90.

SEDIMENT BUDGET

A sediment budget for the Columbia River was used to identify the historic source of shoal material in the navigation channel. Suspended and bedload transport were analyzed, as well as pre- and post-regulation sediment transport.

Suspended Sediment.

The suspended sediment concentrations in the Columbia River are quite low. Measurements taken during the spring freshet in 1922, before any large dams were built, found an average suspended sediment concentration of 130 ppm downstream of the Willamette River (Hickson, 1961). Measurements taken in 1959 and 1960 (USACE Portland, 1961) and in the 1980's (USGS, 1980-1986) found similar concentrations. Based on observed concentrations and appropriate flow-durations curves, the Corps estimated that the average annual suspended sediment yield at Vancouver, WA., has been reduced from 12 mcy/yr pre-regulation to only 2 mcy/yr post-regulation (USACE Portland, 1986).

Not all the suspended sediment in the Columbia River contributes to the shoaling problems. A review of the USGS sediment data indicates 80-90 percent of the suspended sediment is silt or clay, material not found in significant quantities in the bed of the navigation channel. Sand, which makes up about 95 percent of the bed material, is generally less than 15% of the suspended load, and increases to over 30% only when the discharge exceeds 400,000 cfs. This indicates the current average suspended bed material transport into the study area is between 0.2 and 0.6 mcy/yr.

Bedload.

No attempt has been made to directly measure the bedload transport of the Columbia River. However, bedload estimates have been made using two independent methods. An empirical equation developed by the USGS was used to estimate unmeasured load for pre- and post-regulation conditions. That equation is based on the modified Einstein equation and relates unmeasured load to river discharge (USACE Portland, 1986). Applying this equation to the pre- and post-regulation flow-duration curves resulted in bedload estimates of 1.5 mcy/yr pre-regulation and 0.2 mcy/yr post-regulation.

The second estimate was made by equating bedload transport to the movement of the sand waves present on the bed. Sequential surveys were made of two sets of sand waves, one during high flow conditions and the second during average discharge conditions. The analyses of those surveys and flow conditions resulted in bedload estimates ranging from 0.1 mcy/yr to 0.4 mcy/yr. The analysis also found that large sand waves only moved several hundred feet a year.

Shoal Material Sources.

Comparing the average O&M dredging volume of 6.5 mcy/yr to an average total bed material transport rate of 1.0 mcy/yr indicates less material is being transport into the study area than is dredged from the navigation channel. Therefore, the main source of shoal material must be within the study area. Bathymetric surveys (USACE Portland, 1800's-1990) indicate that there has been significant bed degradation in areas adjacent to the most commonly dredged reaches. Experience has also shown that beach erosion occurs at most shoreline disposal sites. These sandy shorelines are much more easily eroded than the natural silt/clay banks. Given the small amount of bed material inflow and the stability of the natural banks, the most likely sources of shoal material are riverbed degradation outside of the navigation channel and erosion from shoreline dredge material disposal sites. Where dredged material has been removed from the active sediment transport system (placed in stable disposal sites), there has been a gradual lowering of riverbed elevations and a corresponding reduction in shoaling.

Shoaling Processes.

The vast majority of the Columbia River navigation channel shoaling is the direct result of bedload transport. The two dominant shoal forms are large sand waves and cutline shoals. Sand waves are present throughout the river channel and cause shoals across the channel where wave crests rise above the channel design depth of -40 ft Columbia River Datum (CRD). Cutline shoals are much larger and run parallel to the channel. Cutline shoals develop at the same locations year after year.

Sand Wave Shoals. Sand waves have long been recognized as a shoaling problem in the Columbia River. Hickson (1930) noted 8- to 10-ft sand waves forming ridges across the 30-ft deep channel. Sand waves create similar shoals in today's 40-ft channel. **Figure 3** shows the variation in size and shape that is typical of this type of shoaling. The volume of an individual sand wave shoal is small, generally less than 30,000 cy, but they are numerous enough to represent a significant amount of the annual O&M dredging.

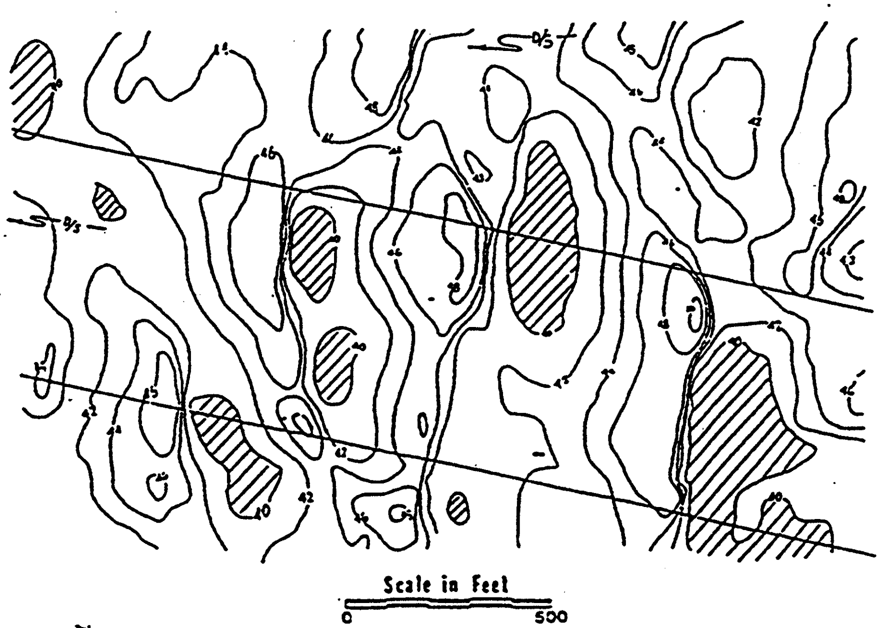

Figure 3. Sand Wave Shoal Pattern.

Sand wave shoals do not appear at the same location each year because of the time required for the waves to form and grow. The 5-ft of advance maintenance dredging utilized in the Columbia River, means the sand waves must grow to 8-to 10-ft high before they become shoals. The main source of material for sand waves is the bed of the navigation channel. Dredging leaves a flat channel bottom on which the waves form. The wave troughs are scoured from below the dredged surface, with material from the trough then forming the wave crest. Because the maximum wave height seldom exceeds 12 ft, sand waves shoals do not occur where the channel bottom is much deeper than 45-ft CRD.

Cutline Shoals. Cutline shoals form along the navigation channel dredging cutline, parallel to flow, and can extend several thousand feet along the channel. Cutline shoals begin forming at the edge of the dredged cut and grow out toward the center of the navigation channel. In the Columbia River, these shoals occur on the inside of long bends and on straight river reaches. They are especially severe in areas of the river that were less than 40-ft deep prior to construction of the existing channel. Cutline shoals are much larger than sand wave shoals, the 12 largest cutline shoals account for nearly half of the annual 6.5 mcy of O&M dredging. Grishanin and Lavygin (1987) concluded that this mechanism is also the main cause of shoaling of dredge cuts in Russian rivers with sandy beds.

The primary cause of cutline shoals is gravity pulling bedload down the side-slopes and into the navigation channel. As river currents move bedload over a bed with a transverse slope, gravity will give the sediment a transverse velocity component independent of the water (Fredsoe, 1978). The steeper the transverse slope, the greater the deflective force on the bedload. Bedload on or near the 1V:3H cutline would therefore be deflected sharply toward the navigation channel. The bedload within the dredged channel would have a very slight, or no, transverse velocity component because of the flat surface of the cut. Along the cutline there would be a convergence of bedload moving downstream in the navigation channel and transversely on the side-slope, resulting in the formation of a shoal. Figure 4 shows the theoretical bedload movement caused by a combination of hydraulic and gravitational forces. This process causes the side-slopes to erode until an equilibrium transverse slope is reached for the deeper channel.
The erosion and resulting shoaling decline as the side-slopes move toward equilibrium conditions.

CURRENT 40-FT CHANNEL MAINTENANCE

The Columbia River navigation channel is currently maintained to minimum dimensions of 40-ft deep by 600-ft wide, by a combination of dredging and river control structures. O&M dredging averages approximately 6.5 mcy/yr. Figure 5 shows the current average annual O&M dredging volumes by bar. This dredging is done by hopper dredges with in-water disposal and pipeline dredges using shoreline or upland disposal.

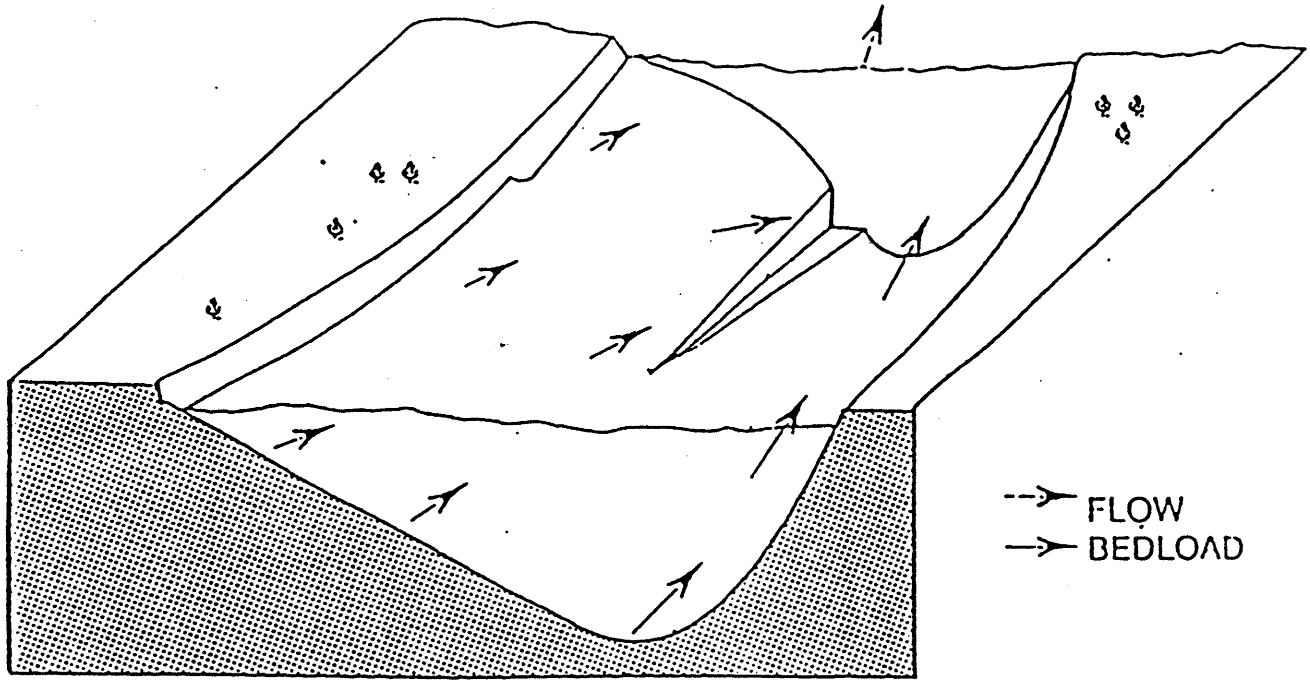

Figure 4. Bedload Transport Paths.

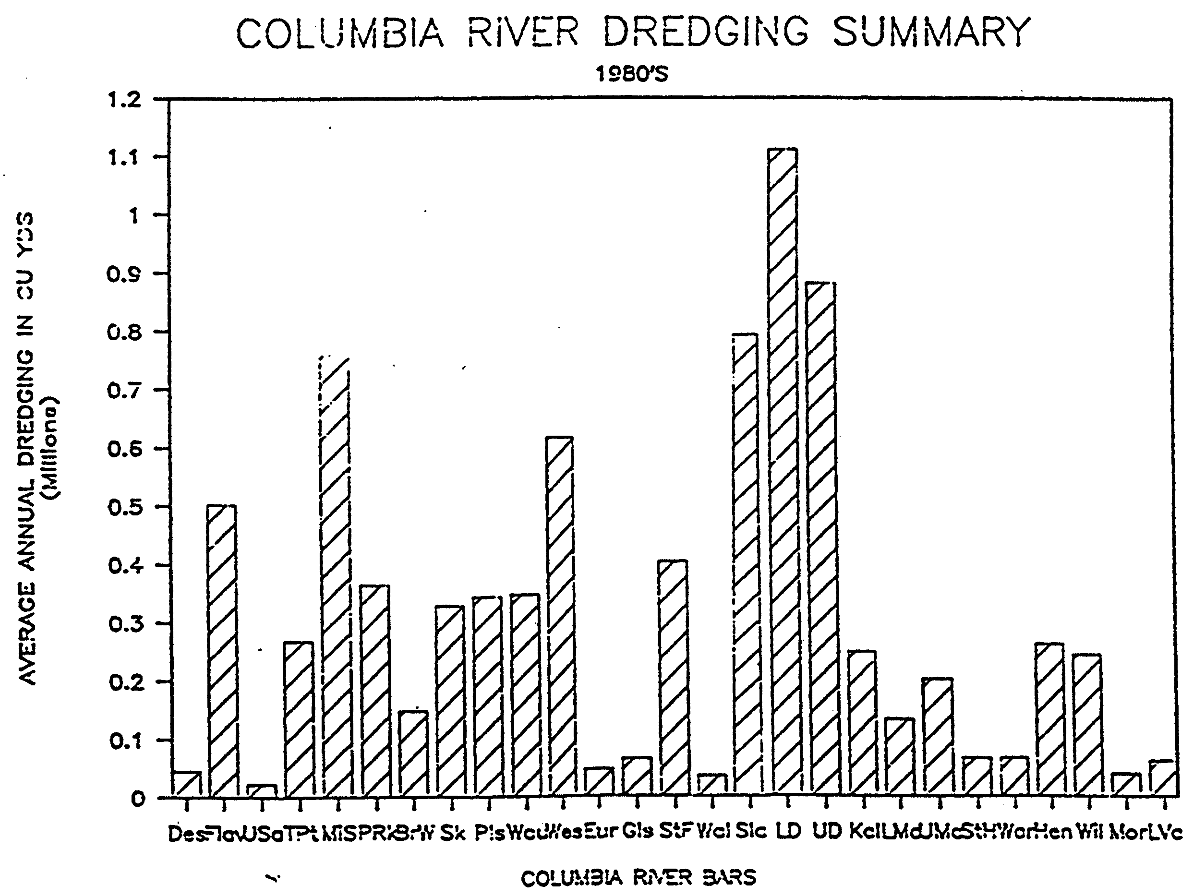

Figure 5. Average Annual O&M Dredging during the 1980's, including Mount St Helens Restoration Work.

Dredging and Disposal Practices.

O&M dredging is generally done by hopper and pipeline dredges. The type of dredge used on a shoal depends on several factors, including dredge availability, size and location of the shoal, and disposal options available. A sand wave skimmer was recently tested in the Columbia River, but did not proved to be an economical maintenance option. If operational improvements are made, the skimmer could be tried again. Dredging beyond the minimum required dimensions is done to increase channel availability and reduce dredging frequency at a bar.

Hopper Dredging. Hopper dredges currently do about 3 mcy/yr of O&M dredging in the Columbia River. Most of this dredging is done by the Corps' hopper dredge "Essayons". Hopper dredges provide flexibility for dredging operations because they can operate anywhere on the river and can be rapidly deployed to problem shoals. Hopper dredges are most often used on small volume shoals, such as sand wave areas, and on larger shoals in the estuary. The "Essayons" may spend several weeks in the early spring and in the fall dredging small shoals in the Columbia River upstream of RM 25. During the summer, the estuary work is done as backup work for the dredging at the mouth of the river. When the entrance becomes too rough or foggy for hopper dredges to work, they will move to one of the estuary shoals to dredge. The main restriction on the use of hopper dredges is the limited availability of in-water disposal sites with enough deep water to allow disposed without creating a new shoal. Flowlane disposal (material is spread in deep-water areas adjacent to the navigation channel) is used for hopper operations upstream of RM 25. In the estuary, hopper disposal is done at a large disposal site (Area D) located away from the navigation channel near RM 6 and a in-water sump near RM 21.

Pipeline Dredging. Pipeline dredges are used for the large cutline shoals and areas with multiple sand wave shoals. About 3.5 mcy/yr are dredged by pipeline dredges, nearly all by the Port of Portland's dredge "Oregon". Pipeline dredging is done during the summer. Typically, the "Oregon" will be scheduled to start at one end of the navigation channel and work its way to the other end. This minimizes the amount of time spent moving the dredge and related equipment. The most common pipeline disposal practice for O&M work is to place material along the shoreline near the dredging site. Many of these shoreline sites are actively eroding and contributing sand back to the navigation channel. Upland disposal is a more effective disposal method, but very few upland sites are available for O&M operations. Occasionally, pipeline disposal will be done in-water adjacent to the navigation channel, but this is not a preferred practice.

Advance Maintenance Dredging. During O&M dredging operations, advance maintenance dredging (AMD) is done beyond the 40-ft by 600-ft dimensions of the navigation channel. The purposes of AMD are to provide year-round channel availability and to allow an annual dredging cycle. AMD of up to 5 ft was authorized for the 40-ft channel. The amount of AMD varies with the type of shoal and dredge. Pipeline dredges are better suited for large cuts than hopper dredges. Pipeline dredges will normally do the full 5 ft of AMD, but hoppers may do from 2 ft to 5 ft of AMD. A review of AMD practices during the Maintenance Improvement Review (USACE, Portland, 1988) found 5 ft AMD to be sufficient to minimize sand wave shoaling problems, but not well suited for the cutline shoals. Based on the recommendations from that review, AMD recently has been done outside the channel boundaries to intercept material moving toward the large cutline shoals.

River Control Structures.

River control structures aid in channel maintenance by controlling flow alignment, reducing erosion, and providing areas for disposal. The current network of control structures provides a smooth channel alignment that reduces erosion and aids navigation. The pile dike fields protect many millions of cubic yards of disposal material from erosion. However, the system has reached, and often exceeded, its limits for disposal site protection. Many shoreline sites have been filled beyond the limits of erosion protection provided by the dike fields and are actively eroding. Recent investigations (USACE, Portland, 1988 & 1990) have recommended construction of additional pile dikes to protect disposal sites at Miller Sands, Pillar Rock, Puget Island, and Westport bars.

BASE CONDITIONS

Base conditions are the 40-ft channel maintenance practices to which future O&M dredging are compared to arrive at the incremental volume of deeper channel alternatives. For this reconnaissance report, it was decided not to use the current O&M practices as the base conditions, but to use the more effecient dredging and disposal practices planned for the 42-ft and 45-ft channels alternatives.

40-Ft Channel Maintenance.

O&M Dredging Forecast. For each bar between RM's 3 and 107, an estimate has been made of future O&M dredging for the 40-ft channel. The 50-yr O&M dredging forecast for the Columbia and Lower Willamette rivers is shown on Figure 6. A decline in dredging is expected to occur as sediment supplies for some of the large cutline shoals are gradually depleted by dredging and upland disposal. This process will be most significant near old shoreline disposal sites. The 50-year O&M dredging forecast totals approximately 225 mcy.

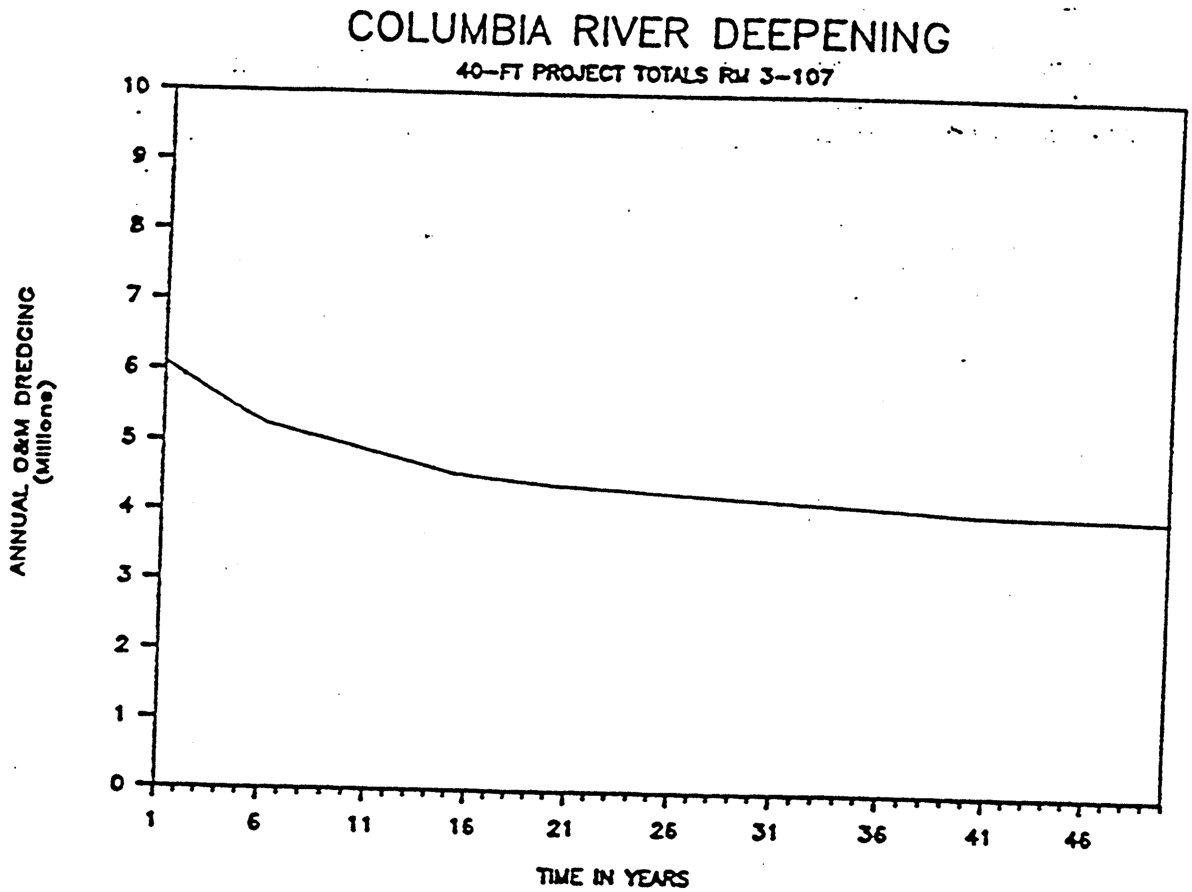

Figure 6. 40-Ft Channel 50-Yr O&M Forecast.

Dredging and Disposal Practices. O&M dredging operations for the 40-ft channel Base Condition are changed from the current practices. Clamshells may join the hopper and pipeline dredges in O&M work, especially in the estuary. Pipeline dredges will still do most of the dredging upstream of RM 20, but disposal will be upland, away from the easily eroded shoreline. More detailed explanations of disposal locations and use are given elsewhere in this report.

Ocean disposal of material from the estuary may make it viable to use clamshells, as well as hopper dredges in the estuary. There will still be a large in-water disposal site in the vicinity of RM 6. This will allow hopper dredges working at the mouth, to continue to work on estuary bars when they can not work at the mouth because of adverse conditions. In the upper estuary, hopper and clamshell dredges will continue to dispose in sumps, where material will be latter rehandled to upland sites. As the navigation channel gets deeper, the availability of good flowlane disposal sites becomes more restricted. However, there are still suitable flowlane sites downstream of Puget Island to allow hopper or clamshell dredges to work the small shoals.

Pipeline dredges will continue to be used in the upper estuary, both to remove shoals and to empty the sumps used by the hopper or clamshell dredges. Disposal sites must be expanded to handle the material expected over the next 50 years. Pipeline dredges will also dredge the large shoals upstream of RM 25. Disposal will be to new upland sites located near the shoals.

Pipeline dredges are planned to do most of the dredging between RM's 20 and 90. For this reconnaissance phase, the important change for the pipeline dredges will be in how they dispose of material. The practice of disposing at unstable shoreline sites will be discontinued and almost all disposal will be in upland sites. Disposal practices will be examined further during the feasibility phase of the project, to determine the most advantageous practices.

Upstream of RM 90, upland disposal sites are hard to locate. In this reach hopper or clamshell dredges will be used so O&M material can be placed in either a small sump near RM 93 and a large sump near RM 103.

AMD was held at 5 ft below authorized depth, including rock areas. Only 2 ft of AMD was used in the Willamette River reach.

WITH PROJECT CONDITIONS

42-FT Channel Alternative.

O&M Dredging Forecast. The 42-ft channel would extend from RM 3 to RM 48 in the Columbia River. This channel would be 600 ft wide and follow the same alignment as the existing 40-ft channel. Upstream of RM 48 the channel would be unchanged from the existing 40-ft channel. Due to the limitations of the current disposal practices discussed earlier, disposal practices will be revised for the new 42-ft channel. More ocean and upland disposal will be done and shoreline (beach nourishment) disposal will generally be stopped.

Over the project life, the 42-ft channel will require 27 mcy more O&M dredging than the 40-ft channel, for a 50-year total of 252 mcy. The majority of the O&M dredging increase will be due to new or larger cutline shoals. The additional 2 ft of depth will increase the amount of material that must erode from side-slopes adjacent to the cutline shoals for the river to reach equilibrium. As shown in Figure 7, the additional material will keep the annual O&M dredging for the 42-ft channel higher than that of the 40-ft channel throughout the project life.

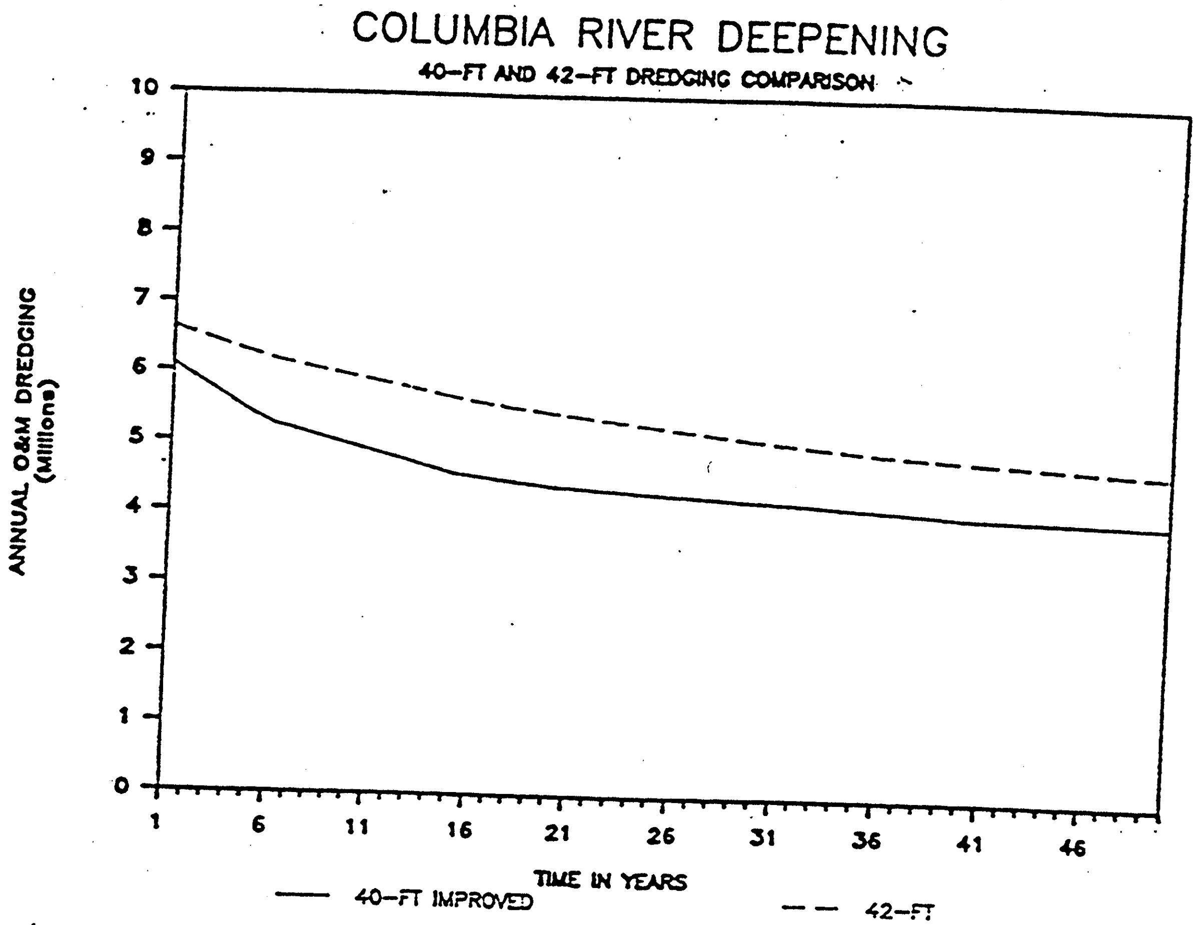

Figure 7. 42-Ft Channel 50-Yr O&M Forecast.

Dredging and Disposal Practices. O&M dredging operations for the 42-ft channel will be the same as those assumed for the Base Condition 40-ft channel maintenance. Clamshells may join the hopper and pipeline dredges in O&M work, especially in the estuary. Pipeline dredges will still do most of the dredging between RM's 20 and 90, but disposal will be upland, away from the easily eroded shoreline. Upstream of RM 90, dredging will be by clamshell and hopper dredges, with disposal at an in-water sump.

AMD will remain at 5 ft below authorized depth, except in rock areas, where only 2 ft is planned. This change will not impact O&M dredging, but may cause problems for very deep draft ships.

No new river control structures are planned for the 42-ft channel.

45-FT Channel Alternative.

The 45-ft channel would extend from RM 3 to RM 107 in the Columbia River and from RM 0 to RM 11 in the Willamette River. Channel alignment and the 600-ft width remain unchanged from the existing 40-ft channel. This channel also will use 5-ft AMD, except for only 2-ft AMD in rock areas and the Willamette River. Because of the greater depth and additional length, the 45-ft channel will increase O&M dredging much more than the 42-ft channel. The channel bottom is very near the riverbed for most of its length. Given the active nature of the Columbia River's bed, this raises the potential for shoaling problems in the navigation channel.

50-Yr O&M Dredging Forecast. A 50-yr O&M dredging forecast was made for the 45-ft channel following the same method as used for the 40- and 42-ft channels. Each bar was examined to determine what type of shoaling can be expected and how much material is available to supply the shoal. It was found that the 45-ft depth would greatly increase the amount of shoals throughout the Columbia River portion of the channel. The O&M dredging is forecast to total 297 mcy over the 50-yr project life. This is 72 mcy more than is forecast for the 40-ft channel Base Condition. Again as with the 40-ft channel, dredging will slowly deplete the available sediment supply as material is transferred from the riverbed to upland disposal sites. The 50-yr dredging forecast is shown in Figure 8. As the sediment supply to the shoals is depleted, there will be a corresponding decline in the annual O&M dredging.

New river control structures were not considered during this phase of study. They could significantly reduce the O&M dredging required to maintain the 45-ft project and should be included in the feasibility phase of this study.

Dredging and Disposal Practices. As with the 40-ft channel Base Condition, the proposed dredging and disposal practices vary along the channel depending on the disposal options available. Hopper, clamshell, and pipeline dredges are all expected to all be used in the 45-ft channel. The lack of stable shoreline disposal sites and suitable flowlane sites lead to a significant increase in upland disposal.

Clamshell dredges are expected to assume some of the dredging currently done by hopper dredges, especially at locations that have long distances to disposal sites. The main work areas for hopper or clamshell dredges will be in the estuary and in the Portland/Vancouver area. In the estuary, ocean disposal is planned for most of the O&M material from downstream of RM 20. An in-water disposal site within the estuary will be maintained for use by hopper dredges that can not work the entrance due to bad weather. An in-water sump near RM 21 can be used by either hopper or clamshell dredges. Material in the sump would be placed in the upland site by a pipeline dredge. Hopper dredge use between RM's 30 and 90 will be very restricted because of the lack of areas deeper than the maximum dredging depth of -50 ft CRD. Hoppers will be able to work only the smaller shoals with very deep water nearby. Upstream of RM 90, upland disposal sites are hard to locate. In this reach hopper or clamshell dredges will be used so O&M material can be placed in either a small sump near RM 93 and a large sump near RM 103. If contaminated material needs to be dredged during project construction, hopper or clamshell dredges could be used to dispose and cap the material in in-water disposal areas.

Pipeline dredges are planned to do most of the dredging between RM's 20 and 90. For this reconnaissance phase, the important change for the pipeline dredges will be in how they dispose of material. The practice of disposing at unstable shoreline sites will be discontinued and almost all disposal will be in upland sites. Disposal practices will be examined further during the feasibility phase of the project.

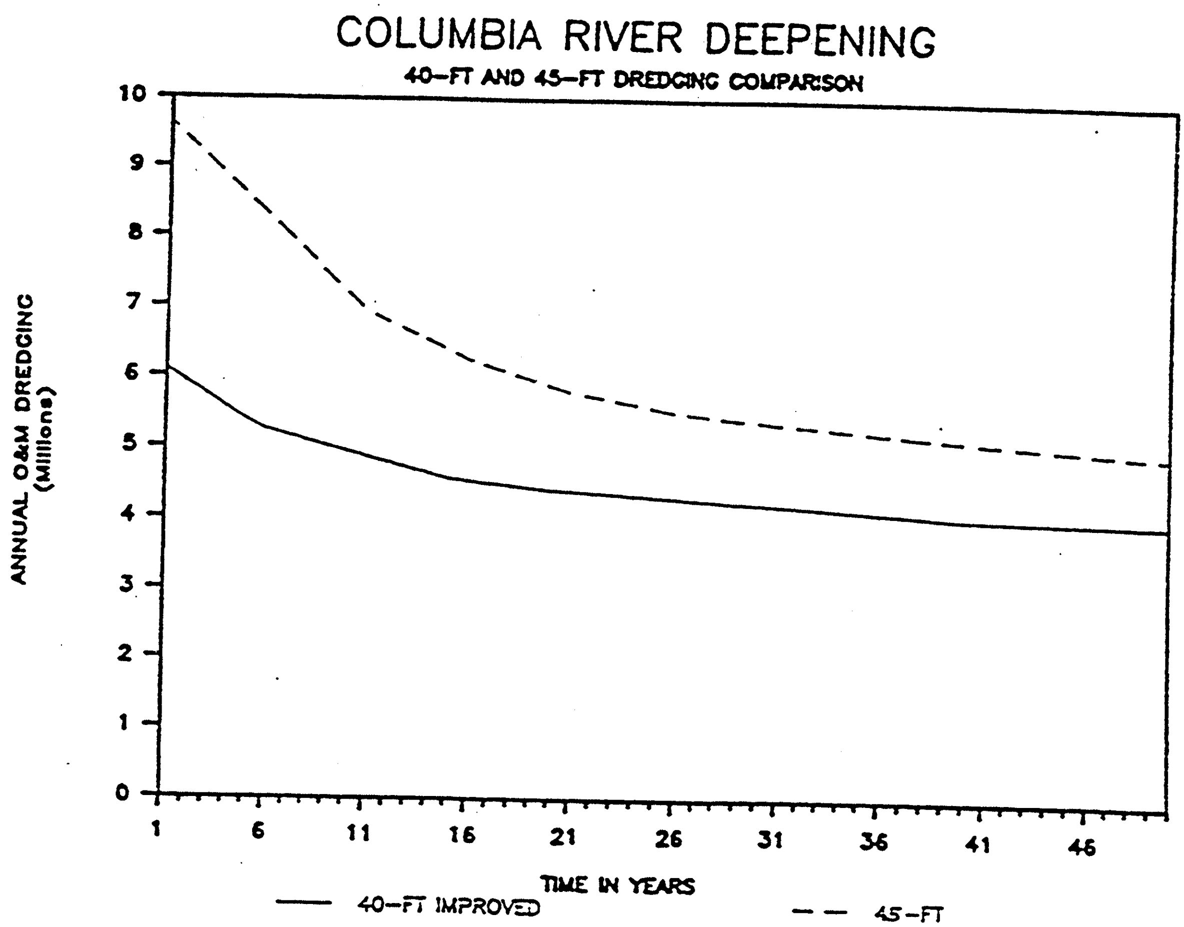

Figure 8. 45-Ft Channel 50-Yr O&M Forecast.

HYDRAULIC AND SEDIMENTATION IMPACTS

The hydraulic and sedimentation impacts of the 42- and 45-ft alternatives will generally be the same type, but will be larger for the deeper and longer 45-ft channel. The potential impacts are discussed only in general terms in the following paragraphs. The specific impacts will depend on the depth, width, and length of the selected navigation channel and location along the rive. While deepening may cause some site specific concerns, the overall impacts will be small compared to those that have occurred during the last 100 years of river development.

Hydraulic Impacts.

The hydraulic impacts of the deepening are expected to be small and will vary depending on location. In the estuary, a deeper channel may result in slightly higher velocities in the main channel. However, the Columbia River Coal Export Channel, Technical Report (USACE, Portland, 1987) suggests that any resulting changes to estuary circulation will be hard to distinguish from normal variations in the existing system. The large disposal sites at Estuarine 1 and 2 will alter local flow patterns, but will be designed to minimize effects on the larger circulation patterns. Upstream of the estuary, the velocity and water surface elevation changes will vary depending on tide, river discharge conditions and location. The channel will not be uniformly deepened, as some reaches are currently deeper than the proposed new depths. In general, one impact might be lower freshet elevations and velocities. Given the wide variation in conditions, it is not possible in this reconnaissance phase to accurately determine the full range of hydraulic impacts. However, the changes are again likely to be so small that they can not be distinguished from existing variations. If specific questions, concerns, or conditions can be identified, then a detailed hydraulic analysis could be performed during the feasibility study.

Sedimentation.

The bed of the Columbia River is not now stable. Bedload movement is the major cause of shoaling in the 40-ft channel. Deepening the navigation channel will increase the instability of the riverbed and result in more shoaling. The deeper cuts will increase the transverse slope of the bed toward the cutline, deflecting more bedload toward the large cutline shoals. As O&M dredging removes sediment from the shoals, more sediment will move from the side-slopes into the shoal areas. Through this process, areas adjacent to the shoals will become deeper, until an equilibrium transverse slope is reached. The effects of this bed erosion are likely to extend all the way to shore and eventually lead to increased shoreline erosion. The shoreline erosion will mainly occur along the sandy beaches created by past dredged material disposal. The erosion of shallow areas in the estuary that is currently occurring, will probably continue for a longer time with a deeper channel. Erosion of the natural silt/clay banks along the Columbia River is not expected to increase significantly. In the Willamette River, the extensive development reduces the potential for shoreline erosion.

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U.S. Army Corps of Engineers, Portland District, 1988, Operational Plan FY88, Lower Columbia River, Maintenance Improvement Review

U.S. Geological Survey, 1980-1986, Water Resources Data, Oregon

APPENDIX D

PROJECT SEDIMENT QUALITY EVALUATIONS

Sediment Evaluations Willamette River

1986 August/September, Lower Willamette. Seven samples were collected and analyzed for physical and volatile organic solids. Sediments were found to be fine-grained high in organics and therefore would require chemical analyses before unconfined in-water disposal would be allowed.

1988 March /April, Lower Willamette. Samples were collected using a gravity corer, ponar grab sampler, and a vibracorer. Physical, volatile solids, ammonia, TOC, metals, pesticides, PAH's, and elutriate testing was performed on the samples. Elutriate and solid-phase bioassays were conducted on material collected at RM4.4, 5.1, 7.1 and 7.3. Sediments from RM 10.7 and downstream consisted of silt with individual sandy or clayey layers. Sediments from RM 11.3 were very sandy in contrast to other sites. At RM 11.7 it was comprised mostly of coarse gravel.

Some sediments had elevated levels for cadmium, copper, mercury, lead, zinc, DDD, and total PAH's. Lead and total PAH concentrations at the Broadway Bridge RM 11.7 were above concern levels. Elevations also occurred with PCB's at RM 10.3, DDT at RM 7.3, and cadmium at the Oregon Slough. Elutriate from Doane Lake sediments was toxic to D. magna, while the less disturbed sediments in the solid phase test were not. Most sediments are acceptable for unconfined in-water disposal in the Columbia River. Shoals from RM 7.0- 7.5, 10.3, and 11.7 should be placed in an alternate confined in-water or upland disposal site.

1989 September, Lower Willamette Supplemental. Elutriate tests were conducted on two samples from the Oregon Slough collected in 1988. Testing was performed by Battelle Pacific Northwest Division Marine Science Laboratory. The bulk chemical tests showed relatively high cadmium levels in November 1988. However results of the elutriate test showed that the release was less than 0.039 mg/L soluble cadmium. Based on these results the sediments are acceptable for unconfined in-water disposal.

1989 July, Burlington Northern Railroad Bridge. Three samples were collected with a vibracore. Each core was split in half logged and subsampled for physical and chemical analysis. Physical analysis revealed that sediment was mostly fines. Chemical analysis reveled that metals, TOC, and oil and grease concentrations were low and typical of uncontaminated river sediment. Pesticides, PCB's, PAH's, phthalates, and phenols were below the method detection limit. Sediment was determined to be acceptable for unconfined in-water disposal.

1992 June, Portland Harbor. The purpose of this study was to evaluate the shoal material in the Lower Willamette River. There were five sample locations. Physical, TOC, volatile organic solids, metals, pesticides, PCB's, PAH's, phenols, and sulfide analysis was performed on some samples. Chemical analysis reveled zinc concentration exceeded the EPA concern level. Very low levels of DDE and DDD were detected in some of the samples. Endosulfan II and methoxchlor was detected in particular samples. PAH's were detected in low concentrations in five of the six samples. One sample exceeded the established concern levels. Phenols were detected in three samples but below concern levels.

From RM 8.0 to 10.2 sediment was determined to be acceptable for unconfined in-water and upland disposal. The sediment sample from RM 10.3 had the most contaminates of all samples. It was anticipated that the this shoal would not be dredged at this time until further evaluations are conducted.

Sediment Evaluations Columbia River

1952-1957, Sediment samples were collected yearly before and after dredging from dredge bins and subjected to physical analysis between July 1952 and September 1957 (form Table 3, DMRP Tech Rpt. D-77-30, Appx. A).

1980-1987, As a result of the eruption of Mt. St. Helens in 1980 and subsequent deposition of large quantities of material in the Columbia River yearly sediment samples were collected between RM 4 and RM 90. Sediment gradations were conducted on suspended and bedload material. A document presenting the results was published in December 1988 by the Sedimentation Section, Hydraulics and Hydrology Branch, Engineering Division, Portland District, USACE.

1982 August, Sediment samples were collected from the main navigation channel from Mouth of the Columbia River to Cathlamet Bay at RM 18.2 and subjected to elutriate and bulk chemical as well as physical analysis. This work was performed by the USGS under contract with the USACE, Portland District. Data is provided in USGS Open File Report 84-133.

1983 July, One sediment sample was collected from the main navigation channel at approximately RM 2.8 and subjected to elutriate and bulk chemical as well as physical analysis. Cadmium was found to be associated with the 1 percent material finer than 100 microns (very fine sand) at a concentration of 2.2 ppm. As the concentration of organic carbon and iron (both of which would hinder biological uptake) was small: it was speculated that the cadmium may be in a form available to benthic organisms. However, bulk concentrations of cadmium in undifferentiated dredged material would be 0.022 ppm (2.2 ppm/100) well below established concern levels. This work was performed by the USGS under contract with the USACE, Portland District. Data is provided in USGS Open File Report 86-4088.

1986 September, Three 30-foot vibracores were collected from the main navigation channel as part of the October 1987 Columbia River Coal Export Channel technical study. The cores were subdivided by depth and various subsamples were subjected to bulk and elutriate chemical as well as physical analyses.

1990 May, Sediment samples for chemical (dioxin/furan and TOC) and physical (grain size and volatile solid) analyses were collected within the proposed channel alignment at various locations along the lower Willamette River (WR) and Columbia River (CR) between Nay 3, 1990 and Nay 18, 1990. Sediment samples were collected from 5 general reaches of the two rivers using a Benthos gravity corer . These reaches included Portland Harbor Area (RN 4+10 to RN 11+00) on the Willamette River and Camas (RN 118+26), St. Helens (RN 85+45), Longview (RN 63+00 to RN 65+40) and Wauna (RN 38+00 to RN 43+05) on the Columbia River.

A total of nineteen (19) samples or composites were analyzed for the presence of dioxins/furans. Though various isomers of dioxin/furan were detected in all of the samples tested many of the individual isomer concentrations found in the Columbia River samples can be attributed to background levels in the analytical system. In addition concentrations found in samples from the Columbia River are orders of magnitude below those found in the Willamette River samples. The isomer 2,3,7,8-TCDD was confirmed in two (2) of the twenty (20) analyses; WRGC-4 at 0.63 pptr and WR-GC-7Rep at 0.62 pptr. The associated furan isomer, 2,3,7,8-TCDF, was detected at concentrations ranging from a low of 0.73 pptr (WR-GC-7) to a high of 110.0 pptr (WR-GC4) in the Willamette River samples. WR-GC-4 was collected from the Doan Lake area where contamination of DDD, DDT and PAHs have been noted in the past.

It was concluded that in the Columbia River, significant dioxin/furan contamination of the sediments within the Columbia River Channel Deepening project is not evident. In the Willamette River, though 2,3,7,8-TCDD and the lower weighted dioxins were found only at low levels, the higher weighted less toxic dioxins and the furans are significantly elevated above background. Further testing and evaluation will be required in this area.

APPENDIX E

PARAMETERS AND METHODS

QA2 DATA REQUIREMENTS

CHEMICAL VARIABLES

ORGANIC COMPOUNDS

The following documentation is needed for organic compounds:

A cover letter referencing or describing the procedure used and discussing any analytical problems

Reconstructed ion chromatograms for GC/MS analyses for each sample

Mass spectra of detected target compounds (GC/MS) for each sample and associated library spectra

GC/ECD and/or GC/flame ionization detection chromatograms for each sample

Raw data quantification reports for each sample

A calibration data summary reporting calibration range used [and decafluorotriphenylphosphine (DFTPP) and bromofluorobenzene (BFB) spectra and quantification report for GC/MS analyses]

Final dilution volumes, sample size, wet-to-dry ratios, and instrument detection limit

Analyte concentrations with reporting units identified (to two significant figures unless otherwise justified)

Quantification of all analytes in method blanks (ng/sample)

Method blanks associated with each sample

Recovery assessments and a replicate sample summary (laboratories should report all surrogate spike recovery data for each sample; a statement of the range of recoveries should be included in reports using these data)

Data qualification codes and their definitions.

METALS

For metals, the data report package for analyses of each sample should include the following:

Tabulated results in units as specified for each matrix in the analytical protocols, validated and signed in original by the laboratory manager

Any data qualifications and explanation for any variance from the analytical protocols

Results for all of the QA/QC checks initiated by the laboratory

Tabulation of instrument and method detection limits.

All contract laboratories are required to submit metals results that are supported by sufficient backup data and quality assurance results to enable independent QA reviewers to conclusively determine the quality of the data. The laboratories should be able to supply legible photocopies of original data sheets with sufficient information to unequivocally identify:

Calibration results

Calibration and preparation blanks

Samples and dilutions

Duplicates and spikes

Any anomalies in instrument performance or unusual instrumental adjustments.

Parameter	Prep Method	Analysis Method	PSDDA SL	PSDDA BT	PSDDA ML	SMS SQS	July 96 draft SMS detection limits (1)	1988 LAET
Chlordane	3540	8081	10	37	---	---	---	---
Dieldrin	3540	8081	10	37	---	---	---	---
Heptachlor	3540	8081	10	37	---	---	---	---
Lindane	3540	8081	10	---	---	---	---	---
Total PCBs	3540	8081	130	38 (13)	2500	12	6	130

1. Recommended Sample Preparation Methods, Cleanup Methods, Analytical Methods and Detection Limits for Sediment Management Standards, Chapter 173-204 WAC, Draft - July 1996.

2. Recommended Protocols for Measuring Conventional Sediment Variables in Puget Sound, Puget Sound Estuary Program, March, 1986.

3. Recommended Methods for Measuring TOC in Sediments, Kathryn Bragdon-Cook, Clarification Paper, Puget Sound Dredged Disposal Analysis Annual Review, May, 1993.

4. units: ug = microgram, mg = milligram, kg = kilogram, dw = dry weight, oc = organic carbon.

5. Test Methods for Evaluating Solid Waste. Laboratory manual physical/chemical methods. Method 3050, SW-846, 3rd ed., Vol 1A, Chapter 3, Sec 3.2, Rev 1. Office of Solid Waste and Emergency Response, Washington, DC.

6. Graphite Furnace Atomic Absorption (GFAA) Spectrometry - SW-846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.

7. Inductively Coupled Plasma (ICP) Emission Spectrometry - SW-846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.

8. Test Methods for Evaluating Solid Waste. Laboratory manual physical/chemical methods. Method 7471, SW-846, 3rd ed., Vol 1A, Chapter 3, Sec 3.3. Office of Solid Waste and Emergency Response, Washington, DC.

9. Sonication Extraction of Sample Solids - Method 3550 (Modified), SW-846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986. Method is modified to add matrix spikes before the dehydration step rather than after the dehydration step.

10. GCMS Capillary Column - Method 8270, SW-846, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.

11. Purge and Trap Extraction and GCMS Analysis - Method 8260, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.

12. Soxhlet Extraction and Method 8081, Test Methods for Evaluating Solid Waste Physical/Chemical Methods, EPA 1986.

13. Total PCBs BT value in mg/kg oc.

Parameter	Prep Method	Analysis Method	PSDDA SL	PSDDA BT	PSDDA ML	SMS SQS	July 96 draft SMS detection limits (1)	1988 LAET
CONVENTIONALS:								
Total Solids (%)	---	Pg.17 (2)	---	---	---	---	---	---
Total Volatile Solids(%)	---	Pg.20 (2)	---	---	---	---	---	---
Total Ofganic Carbon (%)	---	DOE (3)	---	---	---	---	---	---
Grain Size	---	Modified ASTM with Hydrom eter	---	---	---	---	---	---
METALS			units: mg/kg dw (4)			units: mg/kg dw	units: mg/kg dw	
Arsenic	3050 (5)	GFAA (6)	57	507.1	700	57	19	57
Cadmium	3050	GFAA	0.96	---	9.6	5.1	1.7	5.1
Chromium	3050	GFAA	---	---	---	260	87	260
Copper	3050	ICP (7)	81	---	810	390	130	390
Lead	3050	ICP	66	---	660	450	150	450
Mercury	7471 (8)	7471	0.21	1.5	2.1	0.41	0.14	0.59
Nickel	3050	ICP	140	1022	---	---	---	>140
Silver	3050	GFAA	1.2	4.6	6.1	6.1	2.0	>0.56
Zinc	3050	ICP	160	---	1600	410	137	410
ORGANICS								
LPAH			units: ug/kg dw			units: mg/kg oc	units: ug/kg dw	
Naphthalene	3550 (9)	8270 (10)	210	---	2100	99	700	2100

Parameter	Prep Method	Analysis Method	PSDDA SL	PSDDA BT	PSDDA ML	SMS SQS	July 96 draft SMS detection limits (1)	1988 LAET
Acenaphthylene	3550	8270	64	---	640	66	433	>560
Acenaphthene	3550	8270	63	---	630	16	167	500
Fluorene	3550	8270	64	---	640	23	180	540
Phenanthrene	3550	8270	320	---	3200	100	500	1500
Anthracene	3550	8270	130	---	1300	220	320	960
2-Methylnaphthalene	3550	8270	67	---	670	38	223	670
Total LPAH			610	---	6100	370	---	5200
HPAH			units: ug/kg dw			units: mg/kg oc	units: ug/kg dw	
Fluoranthene	3550	8270	630	4600	6300	160	567	1700
Pyrene	3550	8270	430	---	7300	1000	867	2600
Benzo(a)anthracene	3550	8270	450	---	4500	110	433	1300
Chrysene	3550	8270	670	---	6700	110	467	1400
Benzofluoranthenes	3550	8270	800	---	8000	230	1067	3200
Benzo(a)pyrene	3550	8270	680	4964	6800	99	533	1600
Indeno(1,2,3-c,d)pyrene	3550	8270	69	---	5200	34	200	600
Dibenzo(a,h)anthracene	3550	8270	120	---	1200	12	77	230
Benzo(g,h,i)perylene	3550	8270	540	---	5400	31	223	670
Total HPAH			1800	---	51000	960		12000
PESTICIDES & PCBs			units: ug/kg dw			units: mg/kg oc	units: ug/kg dw	
Total DDT	---	---	6.9	50	69	---	---	---
p,p'-DDE	3540 (12)	8081 (12)	---	---	---	---	---	9
p,p'-DDD	3540	8081	---	---	---	---	---	16
p,p'-DDT	3540	8081	---	---	---	---	---	>6
Aldrin	3540	8081	10	37	---	---	---	---

Exhibit B

HARTCROWSER

Earth and Environmental Technologies

Volume I

Sediment Characterization Study of Local Sponsors' Berths; Columbia and Willamette River Navigation Channel Deepening; Longview and Kalama, Washington and Portland, Oregon

Prepared for
Port of Portland

Port Project No. 51773
Port Task No. 22[illegible]

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SEDIMENT CHARACTERIZATION STUDY OF LOCAL PORT SPONSORS' BERTHS; COLUMBIA AND WILLAMETTE RIVER NAVIGATION CHANNEL DEEPENING; LONGVIEW AND KALAMA, WASHINGTON AND PORTLAND, OREGON

1.0 INTRODUCTION

1.1 Project Description

This report presents the results of the sediment characterization study conducted at the Port of Longview and Port of Kalama, Washington, and the Port of Portland, Oregon (see Figure 1). This work was authorized by local port sponsors to support the proposed deepening of the Columbia and Willamette River Navigation Channels. Presently, at many of the grain and container handling facilities at the ports, the water depth at berths is less than the proposed navigational depth and will not accommodate deeper draft vessels once the federal navigational channel is deepened. The purpose of this report is to provide preliminary dredge prism characterization in support of the permitting process for the dredging of the Columbia River Navigation Channel. To meet this objective, two sediment cores were collected at each Dredge Material Management Unit (DMMU) identified in the project area. One composite sediment sample from each DMMU was analyzed for chemical, conventional, and grain size parameters as defined in the Draft Dredge Material Evaluation Framework for the Lower Columbia River Management Area (LCRMA) (Corps *et al.*, 1998).

The proposed Columbia River deepening project will deepen both the Columbia and Willamette River navigation channels. The proposed depth for Columbia River navigation channel is -43 feet (ft) Columbia River Datum (CRD) plus a 5 ft overdepth (-48 ft total depth); while the Willamette River navigation channel is proposed to be deepened to -43 ft CRD plus a 2 ft overdepth (-45 ft total depth).

Within the Portland Harbor, dredging is proposed along Berth 501, Berth 401, Terminal 6, and Irving Street Terminal to maintain future berthing elevations of -43 feet CRD. At the Port of Kalama, dredging is proposed along the Harvest States Grain Terminal and the Peavey Grain Terminal to maintain berth elevation of -43 feet CRD. At the Port of Longview, dredging is proposed along the Longview Grain Wharf to maintain berth elevation of -43 feet CRD. Deepening is not required at the Louis Dreyfuss Terminal in Portland and the United Grain Terminal in Vancouver based on recent hydrographic survey information.

An additional part of this study involved the collection of surface sediment grab samples at twelve deep water locations in the Willamette River (Figures 2 and 3). These samples were collected to supplement sediment sampling conducted in 1997 by the US Army Corps of Engineers (Corps) as part of the Willamette River channel deepening feasibility study. A sediment sample from each grab sample was analyzed for chemical, conventional, and grain size parameters as defined in LCRMA (Corps *et al.*, 1998).

1.2 Report Organization

The main body of this report discusses the results of the sediment characterization study and possible dredge disposal options based on comparison of the sediment characterization data with the LCRMA screening levels (LCRMA-SLs) (Corps *et al.*, 1998). Supporting discussions within the text include sediment sampling locations and any modifications to the Corps approved (pers. comm. Mark Siipola; September, 1998) Sampling and Analysis Plan (SAP) (Hart Crowser, September 3, 1998). The attached appendix presents supporting information including chemical data quality review (Appendix A). Additional procedural details are presented in the SAP (Hart Crowser, September, 1998) that guided this work. Copies of the laboratory certificates of analyses are provided in a separate volume (Appendix B).

2.0 SEDIMENT SAMPLING AND HANDLING

Except for modifications discussed in Section 2.2, all sediment sampling and handling activities were performed in accordance with the Corps-approved SAP (Hart Crowser, 1998). The sampling program was conducted in accordance with LCRMA guidelines to provide full characterization of dredged material.

2.1 Sampling Locations and Methods

Sediment samples were collected from each of the locations shown on Figures 1 through 3 on September 14 through 17, 1998. Tables 1 and 3 present the coordinates of the sampling locations, description of the sediment sample, the sediment elevation (in feet CRD) at the time of sampling, and the length of the collected sediment sample. Surface sediment samples were collected from each of the locations shown on Figures 2 and 3. Tables 2 and 4 present the coordinates of the sampling locations, description of the sediment sample, and the sediment elevation (in feet CRD) at the time of sampling.

2.2 Modifications to the Sampling and Analysis Plan

There were several modifications made to the SAP. Recent bathymetric information indicated that the water depths at the Louis Dreyfuss Terminal at the Port of Portland and the United Grain Terminal at the Port of Vancouver were sufficient to meet navigational requirements and do not require maintenance dredging. Therefore, these terminals were not sampled in this study. Several of the sediment cores (B501-02, B401-01, HS-01, PG-01, and LG-01) were collected in areas with a higher river bed elevation than was initially expected. Although the cores were collected to the maximum depth possible with the vibracore (6 foot cores), these cores are nevertheless a foot shy of the target maximum penetration depth (-45 feet). Therefore, archived sediment samples to characterize the sediment that would be exposed after dredging were not collected at these locations. The other sample locations (B501-01, B401-02, HS-02, PG-02, and LG-02), the riverbed elevation allowed the collection of an archived bottom sediment sample. Additionally, the proposed sediment sampling locations at the Irving Street Terminal were adjusted because a vessel at the berth restricted access to the original proposed locations. Sediment cores were collected near the bow and stern of the vessel (Table 3).

A final minor modification to the SAP was that all the sediment cores were processed in the field immediately upon retrieval. Therefore, there was no need to cap and store the sediment cores prior to processing on land.

2.3 Data Quality Review

A standard data quality review was performed by Hart Crowser on the analytical data package submitted by Columbia Analytical Services and is included as Appendix A of this report. Copies of the laboratory certificates of analyses are provided in a separate volume (Appendix B).

The data quality review concluded that the chemistry data are acceptable for evaluation of sediment disposal options. However, the sample quantitation limit (SQL) for various analytes exceeded the LCRMA-SLs for several of the submitted sediment samples (B401-C1, IS-C1, Grab 5, and Grab 6). If chemical SQLs are higher than the screening levels for a given matrix, a quantitative statement regarding the potential risk for those chemicals cannot be determined. The primary uncertainty is that a chemical may be present above a concentration believed to elicit adverse effects, but below the SQL that could be detected by the analytical method employed. However, for these sediment samples (with the exception of Grab 6), there were other detected chemicals that exceeded LCRMA SLs and in some cases maximum levels (MLs), and the determination of disposal options under Tier II of the LCRMA did not have to be based on SQL exceedences.

3.0 COMPARISON OF CHEMISTRY RESULTS WITH LCRMA SCREENING LEVELS

Sediment chemistry results for the proposed dredge prisms at Berth 501, Terminal 6, Berth 401, and Irving Street Terminal at the Port of Portland; the Harvest States Grain Terminal and the Peavey Grain Terminal at the Port of Kalama; and the Longview Grain Terminal at the Port of Longview; as well as the sediment grab samples from the deep water locations in the Willamette River; were compared to sediment screening levels set forth in the LCRMA for evaluation of suitability for open-water disposal. Two LCRMA sediment quality criteria are provided for comparison with sediment analytical data. First, a lower Screening Level (SL) has been identified for each chemical which corresponds to concentrations below which sediments are acceptable for open water disposal. Second, a higher maximum level (ML) has been defined for each chemical which corresponds to concentrations above which sediments would be unacceptable for unconfined, open water disposal. As per LCRMA guidance, the SL for tributyltin (TBT) is based on a pore water concentration rather than a bulk sediment concentration. Sediment chemistry results are listed in Tables 5 through 9.

3.1 Berth 501

Two sediment cores were collected at this location and were composited into two depth integrated samples (Table 5). For DMMU 1/ B501 (composite sediment sample B501-C1), no metals, semivolatile organic compounds, PCBs, and butyltins were detected above their respective SLs. The only chemical detected above its SL in this DMMU was total DDT. The detected concentration of total DDT in this sample (14.9 µg/kg) slightly exceeded the LCRMA screening level for total DDT (6.9 µg/kg). Based on the exceedence of the LCRMA SL for total DDT, further evaluation of the dredge material from this DMMU is required to determine appropriate disposal options.

Sediments from DMMU 2/ B501 (composite sediment sample B501-C2) were determined to be suitable for unconfined open-water disposal as all detected compounds were at concentrations below corresponding LCRMA SLs.

3.2 Terminal 6

Two sediment cores were collected at this location and were composited into two depth integrated samples (Table 5). For DMMU 1/ T6 (composite sediment sample T6-C1), no semivolatile organic compounds, PCBs, and pesticides were detected above their respective SLs. The only chemical detected above its SL in this DMMU was TBT in pore water. The detected concentration of TBT in this sample (0.33 µg/L) exceeded the LCRMA screening level for TBT (0.15 µg/L). Based on the exceedence of the LCRMA SL for TBT, further evaluation of the dredge material from this DMMU is required to determine appropriate disposal options.

Sediments from DMMU 2/ T6 (composite sediment sample T6-C2) were determined to be suitable for unconfined open-water disposal as all detected compounds were at concentrations below corresponding LCRMA SLs.

3.3 Berth 401

Two sediment cores were collected at this location and were composited into two depth integrated samples (Table 6). For DMMU 1/ B401 (composite sediment sample B401-C1), no metals, volatile organic compounds, or PCBs were detected above their respective SLs. Two PAHs (Pyrene and Fluoranthene) slightly exceeded their respective SLs. The detected concentration of total DDT exceeded the ML. In addition, the sample quantitation limits (SQLs) for several phenols and semivolatile compounds exceeded their respective SLs making comparison with SLs uncertain. Based on the exceedences of various LCRMA SLs and the ML for total DDT, further evaluation of the dredge material from this DMMU is required to determine appropriate disposal options.

Sediments from DMMU 2/ B401 (composite sediment sample B401-C2) were determined to be suitable for unconfined open-water disposal. All measured compounds were at concentrations below the LCRMA SLs.

3.4 Irving Street Terminal

Two sediment cores were collected at this location and were composited into two depth integrated samples (Table 6). For DMMU 1/ IS (composite sediment sample IS-C1), six PAHs were detected above LCRMA MLs and seven PAHs were detected above the LCRMA SLs but below the corresponding MLs. The detected concentration of total PCBs also exceeded the LCRMA ML. In addition, the sample quantitation limits (SQLs) for the pesticides total DDT and chlordane exceeded their respective SLs making comparison with SLs uncertain. Based on the exceedences of the LCRMA SLs and MLs at this DMMU, further evaluation of the dredge material is required to determine appropriate disposal options.

The detected compounds in sediments from DMMU 2/ IS (composite sediment sample IS-C2) were measured at concentrations below the corresponding LCRMA SLs except for total PCB. The detected concentration of total PCBs in sample IS-C2 (710 µg/kg) exceeded the LCRMA SL (130 µg/kg) for total PCB. Based on the exceedence of the LCRMA SL for PCBs, further evaluation of the dredge material is required to determine appropriate disposal options.

3.5 Harvest States Grain Terminal

Two sediment cores were collected at this location and were composited into two depth integrated samples (Table 7). Sediments from DMMU 1/ HS (composite sediment sample HS01-C1) were determined to be suitable for unconfined open-water disposal as all detected compounds were measured at concentrations below the corresponding LCRMA SLs.

All detected compounds in sediments from DMMU 2/ HS (composite sediment sample HS01-C2) were measured at concentrations below the corresponding LCRMA SLs. Sediments from DMMU 2/ HS were determined to be suitable for unconfined open-water disposal.

3.6 Peavey Grain Terminal

Two sediment cores were collected at this location and were composited into two depth integrated samples (Table 7). Sediments from DMMU 1/ PG (composite sediment sample PG01-C1) were determined to be suitable for unconfined open-water disposal as all detected compounds were measured at concentrations below the corresponding LCRMA SLs.

Sediments from DMMU 2/ PG (composite sediment sample PG01-C2) were determined to be suitable for unconfined open-water disposal as all detected compounds were measured at concentrations below the corresponding LCRMA SLs.

3.7 Longview Grain Wharf

Two sediment cores were collected at this location and were composited into two depth integrated samples (Table 8). Sediments from DMMU 1/ LG (composite sediment sample LG01-C1) were determined to be suitable for unconfined open-water disposal as all detected compounds were measured at concentrations below the corresponding LCRMA SLs.

Sediments from DMMU 2/ LG (composite sediment sample LG01-C2) were determined to be suitable for unconfined open-water disposal as all detected compounds were measured at concentrations below the corresponding LCRMA SLs.

3.8 Sediment Grab Samples

The analytical results from the surface sediment grab samples were compared to sediment screening levels set forth in the LCRMA (Table 9). As discussed previously, these samples were collected from deep water locations in the Willamette River to supplement the Corps 1997 channel deepening feasibility study. The results of the comparison of analytical data with LCRMA SLs are summarized below.

GRAB 1. All detected compounds in surface sediment sample Grab 1 were measured at concentrations below the corresponding LCRMA SLs.

GRAB 2. Detected compounds in sediments from surface sediment sample Grab 2 were measured at concentrations below the corresponding LCRMA SLs except for total DDT. The concentration of total DDT detected in Grab 2 (15.5 µg/kg) exceeded the LCRMA SL for total DDT (6.9 µg/kg).

GRAB 3. All detected compounds in surface sediment sample Grab 3 were measured at concentrations below the corresponding LCRMA SLs.

GRAB 4. Detected compounds in sediments from Grab 4 were measured at concentrations below the corresponding LCRMA SLs except for several PAHs and total DDT. The concentrations of three PAHs (fluoranthene, 2600 µg/kg; indeno(1,2,3-cd)pyrene, 980 µg/kg; and pyrene, 3000 µg/kg) in sample Grab 4 exceeded their corresponding LCRMA SLs (1700 µg/kg, 600 µg/kg, and 2600 µg/kg). The LCRMA SL for total DDT (6.9 µg/kg) was exceeded in sample Grab 4 (65.9 µg/kg).

GRAB 5. In this sample, the concentrations of fourteen PAHs were detected above the LCRMA MLs. The detected concentration of total DDT in this sample (25 µg/kg) exceeded the LCRMA SL (6.9 µg/kg). In addition, the SQLs for two PAHs, all of the phenols, all of the phthalates, and all of the semivolatile organic compounds exceeded LCRMA SLs and in some cases MLs making comparison with SLs and MLs uncertain.

GRAB 6. Detected compounds in sediments from Grab 6 were measured at concentrations below the corresponding LCRMA SLs. However, the SQLs for 2,4-dimethylphenol, hexachlorobenzene, hexachlorobutadiene, and N-nitrosodiphenylamine exceeded LCRMA SLs making comparison with SLs uncertain.

GRAB 7. All detected compounds in surface sediment sample Grab 7 were measured at concentrations below the corresponding LCRMA SLs.

GRAB 8. All detected compounds in surface sediment sample Grab 8 were measured at concentrations below the corresponding LCRMA SLs.

GRAB 9. All detected compounds in surface sediment sample Grab 9 were measured at concentrations below the corresponding LCRMA SLs.

GRAB 10. All detected compounds in surface sediment sample Grab 10 were measured at concentrations below the corresponding LCRMA SLs.

GRAB 11. All detected compounds in surface sediment sample Grab 11 were measured at concentrations below the corresponding LCRMA SLs.

GRAB 12. All detected compounds in surface sediment sample Grab 1 were measured at concentrations below the corresponding LCRMA SLs.

4.0 LIMITATIONS

Work for this project was performed, and this report prepared, in accordance with generally accepted professional practices for the nature and conditions of the work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of Port of Portland for specific application to the referenced properties. This report is not meant to represent a legal opinion. No other warranty, express or implied, is made.

Any questions regarding our work and this report, the presentation of the information, and the interpretation of the data are welcome and should be referred to the undersigned.

Please feel free to contact us with any questions or comments.

Sincerely,

HART CROWSER, INC.

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EXPIRES: DEC. 31, 1999

5.0 REFERENCES

Corps et al., 1998. Dredged Material Evaluation Framework, Lower Columbia River Management Area. Draft April 1998.

Hart Crowser, 1998. Sampling and Analysis Plan, Sediment Testing for Full Characterization of Proposed Dredged Material, Longview, Kalama, and Vancouver, Washington, and Portland, Oregon. September 3, 1998.

Table 1 - Discrete Core Sample Description

Core Sample Identification	Sample Depth Interval in Feet [1]	Visual Sediment Description
Berth 501		
B501-01	0.0 to 6.0	Brown-gray, slightly silty, medium SAND with sheen at four feet
B501-02	0.0 to 5.0	Brown-gray, slightly silty, medium SAND
Terminal 6		
T6-01	0.0 to 3.5	Olive, slightly sandy SILT
	3.5 to 5.0	Olive-black, silty SAND with wood debris
T6-02	0.0 to 3.5	Olive, slightly sandy SILT
	3.5 to 6.0	Olive-black, silty SAND with wood debris
T6-03	0.0 to 3.5	Olive, slightly sandy SILT
	3.5 to 5.0	Olive-black, silty SAND with wood debris
Berth 401		
B401-01	0.0 to 1.0	Gray-brown, sandy SILT
	1.0 to 3.0	Gray-brown, sandy SILT with wood debris and silt laminates
	3.0 to 5.0	Gray, medium SAND
B401-02	0.0 to 1.0	Gray-brown, sandy SILT
	1.0 to 3.0	Gray-brown, sandy SILT with wood debris and silt laminates
	3.0 to 4.5	Gray, medium SAND
Irving Street		
IS-01	0.0 to 2.0	Olive, loose, SILT with wood fragments
	2.0 to 5.9	Black, medium coarse SAND
IS-02	0.0 to 2.0	Olive, loose, SILT with wood fragments and occasional sheen
	2.0 to 5.8	Black, medium coarse SAND
Harvest States		
HS-01	0 to 1.0	Olive, slightly silty SAND
	1.0 to 5.0	Gray, slightly silty SAND
HS-02	0 to 1.0	Olive, slightly silty SAND
	1.0 to 6.0	Gray, slightly silty SAND
Peavey Grain		
PG-01	0 to 2.0	Brown, slightly gravelly SAND
	2.0 to 5.0	Brown, gravelly SAND
PG-02	0 to 2.0	Brown, slightly gravelly SAND
	2.0 to 5.0	Brown, gravelly SAND
Longview Grain		
LG-01	0 to 3.0	Olive, silty SAND
	3.0 to 6	Dark gray, slightly silty SAND
LG-02	0 to 3.0	Olive, silty SAND
	3.0 to 6	Dark gray, slightly silty SAND

Notes:
1. Depth is not compaction corrected.

Table 2 - Surface Sediment Sample Description

Grab Sample Identification	Sample Depth Interval in Feet	Visual Sediment Description
Grab-01	0.67	Olive-gray, slightly sandy SILT, worm burrows
Grab-02	0.67	Olive-gray, slightly sandy SILT to 4"; Black med-fine SAND to 8", worm burrows
Grab-03	0.67	Olive-gray, very sandy SILT to 4"; Black med-fine slightly silty SAND to 8", worm burrows
Grab-04	0.67	Olive-brown SILT, slight sheen
Grab-05	0.67	Brown SILT to 2"; Brown-black coarse SAND to 8", slight sheen
Grab-06	0.67	Black, slightly silty SAND
Grab-07	0.67	Brown-olive, sandy SILT with wood debris and worm burrows
Grab-08	0.67	Gray-olive, loose SILT
Grab-09	0.67	Olive, loose SILT to 7", Black coarse SAND to 8"
Grab-10	0.67	Olive, loose SILT to 7"; Black coarse SAND to 8"
Grab-11	0.67	Olive, loose SILT with wood debris and worm burrows
Grab-12	0.67	Olive, loose SILT to 4"; Black med-coarse SAND to 8", worm burrows

Table 3 - Summary of Field Sampling Results for Core Samples

Sample Location	North Latitude	West Longitude	Mudline Elevation in Feet CRD	Core Penetration in Feet	Sample Recovery in Feet	Estimated Core Compaction in Percent	Core Penetration Elevation in Feet CRD	Notes
Berth 501								
B501-01	45° 38.531'	122° 46.359'	-40.0	6.0	6.0	0.0	-46.0	
B501-02	45° 38.486'	122° 46.437'	-39.0	6.0	5.0	16.7	-44.8	Full dredge depth not achieved.
Terminal 6								
T6-01	45° 38.528'	122° 45.010'	-40.0	6.0	5.0	16.7	-45.8	
T6-02	45° 38.449'	122° 44.926'	-40.0	6.0	6.0	0.0	-46.0	
T6-03	45° 38.314'	122° 44.727'	-40.0	5.0	5.0	0.0	-45.0	No archive sample collected from core.
Berth 401								
B401-01	45° 36.318'	122° 46.820'	-40.0	6.0	5.0	16.7	-45.8	
B401-02	45° 36.292'	122° 46.813'	-41.0	6.0	4.5	25.0	-46.6	
Irving Street								
IS-01	45° 32.091'	122° 40.478'	-40.5	6.0	5.9	1.7	-46.5	Vessel at berth. Sample collected near bow of vessel.
IS-02	45° 32.413'	122° 40.590'	-40.5	6.0	5.8	3.3	-46.5	Vessel at berth. Sample collected near stern of vessel.
Harvest States								
HS-01	45° 59.012'	122° 50.051'	-42	6.0	5.0	16.7	-47.8	Full dredge depth not achieved.
HS-02	45° 59.007'	122° 50.035'	-42	6.0	6.0	0.0	-48.0	
Peavey Grain								
PG-01	46° 01.560'	122° 52.063'	-41	5.0	5.0	0.0	-46.0	Full dredge depth not achieved.
PG-02	46° 01.569'	122° 52.047'	-41	5.0	5.0	0.0	-46.0	Full dredge depth not achieved.
Longview Grain								
LG-01	46° 06.271'	122° 57.121'	-39	6.0	6.0	0.0	-45.0	Full dredge depth not achieved.
LG-02	46° 06.275'	122° 57.110'	-40	6.0	6.0	0.0	-46.0	Full dredge depth not achieved.

(NAD 83)

Table 4 - Summary of Field Sampling Results for Surface Sediment Samples

Sample Location	North Latitude	West Longitude	Mudline Elevation in Feet CRD	Approximate River Mile
Grab-01	45° 35.311'	122° 46.800'	-70	4.5
Grab-02	45° 35.980'	122° 46.639'	-74	4.8
Grab-03	45° 35.665'	122° 46.378'	-78	5.1
Grab-04	45° 34.926'	122° 45.593'	-57	6.1
Grab-05	45° 34.955	122° 45.512'	-50	6.1
Grab-06	45° 34.886'	122° 45.333'	-48	6.3
Grab-07	45° 34.394'	122° 44.259'	-63	7.3
Grab-08	45° 34.019'	122° 43.821'	63	7.9
Grab-09	45° 33.225'	122° 42.203'	-73	9.4
Grab-10	45° 33.103'	122° 41.914'	-64.5	9.7
Grab-11	45° 32.639'	122° 41.403'	-76	10.5
Grab-12	45° 32.356'	122° 41.021'	-66	10.8

(NAD 27)

Table 5 - Draft Analytical Results for Sediment Samples; Berth 501 and Terminal 6

Sample ID Lab ID Sampling Date Sampling Depth Interval	LCRMA SL	LCRMA ML	B501-C1 K9806351-009 9/14/98 0 to 3 ft	B501-C2 K9806351-010 9/14/98 3 to 5 ft	T6-C1 K9806423-001 9/16/98 0 to 3 ft	T6-C2 K9806423-002 9/16/98 3 to 5 ft
Conventionals						
Ammonia as Nitrogen			70.5	119	140	83.7
Carbon, Total Organic (TOC)			0.54	0.52	0.87	0.64
Solids, Total			62.1	69.6	58.9	63.6
Solids, Total Volatile			5.72	2.79	4.67	3.27
Sulfide, Total			41	45	13.1	100
Metals in mg/kg						
Antimony, Total	150	200	0.05	0.03	0.05	0.04 U
Arsenic, Total	57	700	2.6	1.2	2	2
Cadmium, Total	5.1	14	0.85	0.44	0.64	0.78
Chromium, Total			16.3	13.3	11.7	11.2
Copper, Total	390	1300	19.7	14.7	18.3	16.4
Lead, Total	450	1200	18.2	11.1	10	9.65
Mercury, Total	0.41	2.3	0.11	0.05	0.07	0.06
Nickel, Total	140	370	16.2	16.1	12.1	11.1
Silver, Total	6.1	8.4	0.18	0.16	0.13	0.14
Zinc, Total	410	3800	112	75.5	88	101
Organometallics in µg/L						
Tri-n-butyltin	0.15		0.03		0.33	
LPAHs in µg/kg						
Acenaphthene	500	2000	33	28	20 U	20 U
Acenaphthylene	560	1300	20 U	20 U	20 U	20 U
Anthracene	960	13000	35	20 U	20 U	31
Fluorene	540	3600	20 U	22	20 U	23
Naphthalene	2100	2400	50	20 U	20 U	20 U
Phenanthrene	1500	21000	250	140	56	120
Total LPAHs	5200	29000	368	190	56	174
HPAHs in µg/kg						
Benz(a)anthracene	1300	5100	130	34	52	56
Benzo(a)pyrene	1600	3600	180	38	35	40
Benzo(b)fluoranthene			120	32	42	49
Benzo(g,h,i)perylene	670	3200	100	23	20 U	28
Benzo(k)fluoranthene			100	26	36	47
Chrysene	1400	21000	160	42	55	86
Dibenz(a,h)anthracene	230	1900	20	20 U	20 U	20 U
Fluoranthene	1700	30000	300	93	120	170
Indeno(1,2,3-cd)pyrene	600	16000	130	30	23	38
Pyrene	2600	16000	390	120	110	140
Total Benzofluoranthenes	3200	9900	220	58	78	96
Total HPAHs	12000	69000	1630	438	473	654
Phenols in µg/kg						
2,4-Dimethylphenol	29	210	6 U	6 U	6 U	6 U
2-Methylphenol	63	77	6 U	6 U	6 U	6 U
4-Methylphenol	670	3600	77	20 U	20 U	20 U
Pentachlorophenol (PCP)	400	690	61 U	61 U	61 U	61 U
Phenol	420	1200	20 U	20 U	20 U	20 U
Phthalates in µg/kg						
Bis(2-ethylhexyl) Phthalate	8300		56	36	450	30
Butyl Benzyl Phthalate	970		20 U	20 U	190	20 U
Di-n-butyl Phthalate	5100		20 U	20 U	20 U	20 U

Table 5 - Draft Analytical Results for Sediment Samples; Berth 501 and Terminal 6

Sample ID			B501-C1	B501-C2	T6-C1	T6-C2
Lab ID			K9806351-009	K9806351-010	K9806423-001	K9806423-002
Sampling Date	LCRMA	LCRMA	9/14/98	9/14/98	9/16/98	9/16/98
Sampling Depth Interval	SL	ML	0 to 3 ft	3 to 5 ft	0 to 3 ft	3 to 5 ft
Di-n-octyl Phthalate	6200		20 U	20 U	20 U	20 U
Diethyl Phthalate	1200		20 U	20 U	20 U	20 U
Dimethyl Phthalate	1400		20 U	20 U	20 U	20 U
Semivolatiles in µg/kg						
Benzoic Acid	650	760	100 U	100 U	100 U	100 U
Benzyl Alcohol	57	870	6 U	6 U	6 U	6 U
Dibenzofuran	540	1700	20 U	20 U	20 U	20 U
Hexachlorobenzene	22	230	20 U	20 U	20 U	20 U
Hexachlorobutadiene	29	290	20 U	20 U	20 U	20 U
N-Nitrosodiphenylamine	28	130	12 U	12 U	12 U	12 U
Volatiles in µg/kg						
1,2-Dichlorobenzene	35	110	1 U	1 U	1 U	1 U
1,3-Dichlorobenzene	170		1 U	1 U	1 U	1 U
1,4-Dichlorobenzene	110	120	1 U	1 U	1 U	1 U
Pesticide/PCBs in µg/kg						
4,4'-DDD			9.9	3.9	2 U	2 U
4,4'-DDE			5	2.6	2	2
4,4'-DDT			6.7 U	6.7 U	2 U	2 U
Total DDT	6.9	69	14.9	6.5	2	2
Aldrin	10		1.7 U	1.7 U	2 U	2 U
Aroclor 1016			10 U	10 U	10 U	10 U
Aroclor 1221			10 U	10 U	10 U	10 U
Aroclor 1232			10 U	20 U	10 U	10 U
Aroclor 1242			22	10 U	10 U	10 U
Aroclor 1248			10 U	20 U	10 U	10 U
Aroclor 1254			20 U	15 U	10 U	10 U
Aroclor 1260			13	14	10 U	10 U
Total PCBs	130	3100	35	14	10 U	10 U
Chlordane	10					
Dieldrin	10		2.3 U	2.3 U	2 U	2 U
Endosulfan I					2 U	2 U
Endosulfan II					2 U	2 U
Endosulfan Sulfate					2 U	2 U
Endrin					2 U	2 U
Endrin Aldehyde					2 U	2 U
Endrin Ketone					2 U	2 U
Heptachlor	10		1.7 U	1.7 U	2 U	2 U
Heptachlor Epoxide					2 U	2 U
Methoxychlor					4 U	4 U
Toxaphene					30 U	30 U
alpha-BHC					2 U	2 U
alpha-Chlordane			1.7 U	1.7 U	2 U	2 U
beta-BHC					2 U	2 U
delta-BHC					2 U	2 U
gamma-BHC (Lindane)	10		1.7 U	1.7 U	2 U	2 U
gamma-Chlordane			1.7 U	1.7 U	2 U	2 U

Notes: [solid box] Exceeds LCRMA SL

[dotted box] SQLs Exceeds LCRMA SL

Table 6 - Analytical Results for Sediment Samples; Berth 401 and Irving St.

Sample ID			B401-C1	B401-C2	IS-C1	IS-C2
Lab ID			K9806351-012	K9806351-013	K9806410-008	K9806410-009
Sampling Date	LCRMA	LCRMA	9/14/98	9/14/98	9/15/98	9/15/98
Sampling Depth Interval	SL	ML	0 to 3 ft	3 to 5 ft	0 to 3 ft	3 to 5 ft
Conventionals						
Ammonia as Nitrogen			209	154	65 UJ/J	100 UJ/J
Carbon, Total Organic (TOC)			1.63	0.53	1.03	0.91
Solids, Total			54	70.4		
Solids, Total Volatile			6.2	2.64		
Sulfide, Total			28	32	58	2
Metals in mg/kg						
Antimony, Total	150	200	0.02 U	0.03	0.19 UJ/J	0.26 UJ/J
Arsenic, Total	57	700	1.3	1	1.9	2.1
Cadmium, Total	5.1	14	0.33 J	0.14 J	0.26	0.26
Chromium, Total			16.1	10.9	19.1	47.8
Copper, Total	390	1300	21.8	14.4	26.6 UJ/J	25.6 UJ/J
Lead, Total	450	1200	12.4	9.8	29	367
Mercury, Total	0.41	2.3	0.21	0.08	0.07	0.08
Nickel, Total	140	370	16.1	15.3	20.1	25.5
Silver, Total	6.1	8.4	0.2	0.12	0.18	0.2
Zinc, Total	410	3800	87.6	53.4	90.1	115
Organometallics in µg/L						
Tri-n-butyltin	0.15		0.04		0.05	
LPAHs in µg/kg						
Acenaphthene	500	2000	210	38	34	20 U
Acenaphthylene	560	1300	200 U	20 U	240	20 U
Anthracene	960	13000	250	46	2200	20 U
Fluorene	540	3600	200 U	27	190	20 U
Naphthalene	2100	2400	290	95	190	20 U
Phenanthrene	1500	21000	1100	260	6800	45
Total LPAHs	5200	29000	1850	466	9654	45
HPAHs in µg/kg						
Benz(a)anthracene	1300	5100	690	170	6400	37
Benzo(a)pyrene	1600	3600	710	220	7300	61
Benzo(b)fluoranthene			460	140	2900	31
Benzo(g,h,i)perylene	670	3200	380	140	4400	270
Benzo(k)fluoranthene			450	130	5100	26
Chrysene	1400	21000	740	190	8100	40
Dibenz(a,h)anthracene	230	1900	200 U	20 U	660	53
Fluoranthene	1700	30000	2200	430	16000	98
Indeno(1,2,3-cd)pyrene	600	16000	410	180	4600	360
Pyrene	2600	16000	2700	540	19000	110
Total Benzofluoranthenes	3200	9900	910	270	8000	57
Total HPAHs	12000	69000	8740	2140	74460	1086
Phenols in µg/kg						
2,4-Dimethylphenol	29	210	60 U	6 U	6 U	6 U
2-Methylphenol	63	77	60 U	6 U	6 U	6 U
4-Methylphenol	670	3600	200 U	23	44	52
Pentachlorophenol (PCP)	400	690	610 U	61 U	61 U	61 U
Phenol	420	1200	200 U	20 U	20 U	20 U
Phthalates in µg/kg						
Bis(2-ethylhexyl) Phthalate	8300		200 U	20 U	220	160
Butyl Benzyl Phthalate	970		240	20 U	28	20 U
Di-n-butyl Phthalate	5100		200 U	20 U	20 U	20 U

Table 6 - Analytical Results for Sediment Samples; Berth 401 and Irving St.

Sample ID / Lab ID / Sampling Date / Sampling Depth Interval	LCRMA SL	LCRMA ML	B401-C1 K9806351-012 9/14/98 0 to 3 ft	B401-C2 K9806351-013 9/14/98 3 to 5 ft	IS-C1 K9806410-008 9/15/98 0 to 3 ft	IS-C2 K9806410-009 9/15/98 3 to 5 ft
Di-n-octyl Phthalate	6200		200 U	20 U	20 U	20 U
Diethyl Phthalate	1200		200 U	20 U	20 U	20 U
Dimethyl Phthalate	1400		200 U	20 U	20 U	20 U
Semivolatiles in µg/kg						
Benzoic Acid	650	760	1000 U	100 U	100 U	100 U
Benzyl Alcohol	57	870	60 U	6 U	6 U	6 U
Dibenzofuran	540	1700	200 U	20 U	27	20 U
Hexachlorobenzene	22	230	200 U	20 U	20 U	20 U
Hexachlorobutadiene	29	290	200 U	20 U	20 U	20 U
N-Nitrosodiphenylamine	28	130	120 U	12 U	12 U	12 U
Volatiles in µg/kg						
1,2-Dichlorobenzene	35	110	1 U	1 U	1 U	1 U
1,3-Dichlorobenzene	170		1 U	1 U	1 U	1 U
1,4-Dichlorobenzene	110	120	1 U	1 U	1 U	1 U
Pesticide/PCBs in µg/kg						
4,4'-DDD			14	5.1	20 U	2 U
4,4'-DDE			5.8	2.3 U	20 U	2 U
4,4'-DDT			460	6.7 U	20 U	2 U
Total DDT	6.9	69	479.8	5.1	20 U	2 U
Aldrin	10		1.7 U	1.7 U	2 U	2 U
Aroclor 1016			10 U	10 U	10 U	10 U
Aroclor 1221			10 U	10 U	10 U	10 U
Aroclor 1232			10 U	10 U	10 U	10 U
Aroclor 1242			10 U	10 U	10 U	10 U
Aroclor 1248			10 U	10 U	10 U	10 U
Aroclor 1254			25 U	10 U	10 U	10 U
Aroclor 1260			32	12	7100	710
Total PCBs	130	3100	32	12	7100	710
Chlordane	10					
Dieldrin	10		2.3 U	2.3 U	65 U	2 U
Endosulfan I					20 U	2 U
Endosulfan II					20 U	2 U
Endosulfan Sulfate					20 U	2 U
Endrin					20 U	2 U
Endrin Aldehyde					20 U	2 U
Endrin Ketone					190 U	15 U
Heptachlor	10		1.7 U	1.7 U	20 U	2 U
Heptachlor Epoxide					2 U	2 U
Methoxychlor					2 U	2 U
Toxaphene					40 U	4 U
alpha-BHC					300 U	300 U
alpha-Chlordane			1.7 U	1.7 U	2 U	2 U
beta-BHC					20 U	2 U
delta-BHC					2 U	2 U
gamma-BHC (Lindane)	10		1.7 U	1.7 U	2 U	2 U
gamma-Chlordane			1.7 U	1.7 U	20 U	3 U

Notes: [box] Exceeds LCRMA SL; [dotted box] SQLs Exceeds LCRMA SL; [double box] Exceeds LCRMA ML

Table 7 - Analytical Results for Sediment Samples; Harvest States and Peavey Grain

Sample ID Lab ID Sampling Date Sampling Depth Interval	LCRMA SL	LCRMA ML	HS-01-C1 K9806462-001 9/17/98 0 to 3 ft	HS01-C2 K9806462-002 9/17/98 3 to 5 ft	PG01-C1 K9806462-004 9/17/98 0 to 3 ft	PG01-C2 K9806462-005 9/17/98 3 to 5 ft
Conventionals						
Ammonia as Nitrogen			7.6	20.8	0.4	2.8
Carbon, Total Organic (TOC)			0.05	0.07	0.1	0.05 U
Solids, Total			80.5	77	78.5	82.8
Solids, Total Volatile			1.01	1.11	1.28	1.07
Sulfide, Total			0.7 U	0.7 U	0.7 U	0.7 U
Metals in mg/kg						
Antimony, Total	150	200	0.04 UJ/J	0.04 UJ/J	0.04 UJ/J	0.04 UJ/J
Arsenic, Total	57	700	0.6 J	0.5 J	0.4 J	0.4 J
Cadmium, Total	5.1	14	0.18	0.1	0.08	0.03 J
Chromium, Total			4.7	3.6	3.6	1.6
Copper, Total	390	1300	7.5	11.3	8.4	9.2
Lead, Total	450	1200	2.26	1.14	1.83	1.01
Mercury, Total	0.41	2.3	0.02 U	0.02 U	0.02 U	0.02 U
Nickel, Total	140	370	6.5	5	6.2	4.7
Silver, Total	6.1	8.4	0.05	0.01 J	0.03 J	0.02 J
Zinc, Total	410	3800	27	16	20	14
Organometallics in µg/L						
Tri-n-butyltin	0.15		0.02 UJ/J		0.02 UJ/J	
LPAHs in µg/kg						
Acenaphthene	500	2000	20 U	68	20 U	20 U
Acenaphthylene	560	1300	20 U	20 U	20 U	20 U
Anthracene	960	13000	20 U	20 U	20 U	20 U
Fluorene	540	3600	20 U	20 U	20 U	20 U
Naphthalene	2100	2400	20 U	20 U	20 U	20 U
Phenanthrene	1500	21000	20 U	20 U	20 U	20 U
Total LPAHs	5200	29000	20 U	68	20 U	20 U
HPAHs in µg/kg						
Benz(a)anthracene	1300	5100	20 U	20 U	20 U	20 U
Benzo(a)pyrene	1600	3600	20 U	20 U	20 U	20 U
Benzo(b)fluoranthene			20 U	20 U	20 U	20 U
Benzo(g,h,i)perylene	670	3200	20 U	20 U	20 U	20 U
Benzo(k)fluoranthene			20 U	20 U	20 U	20 U
Chrysene	1400	21000	20 U	20 U	20 U	20 U
Dibenz(a,h)anthracene	230	1900	20 U	20 U	20 U	20 U
Fluoranthene	1700	30000	20 U	20 U	20 U	20 U
Indeno(1,2,3-cd)pyrene	600	16000	20 U	20 U	20 U	20 U
Pyrene	2600	16000	20 U	20 U	20 U	20 U
Total Benzofluoranthenes	3200	9900	20 U	20 U	20 U	20 U
Total HPAHs	12000	69000	20 U	20 U	20 U	20 U
Phenols in µg/kg						
2,4-Dimethylphenol	29	210	6 U	6 U	6 U	6 U
2-Methylphenol	63	77	6 U	6 U	6 U	6 U
4-Methylphenol	670	3600	20 U	20 U	20 U	20 U
Pentachlorophenol (PCP)	400	690	61 U	61 U	61 U	61 U
Phenol	420	1200	20 U	20 U	20 U	20 U
Phthalates in µg/kg						
Bis(2-ethylhexyl) Phthalate	8300		26	20 U	20 U	20 U
Butyl Benzyl Phthalate	970		20 U	20 U	20 U	20 U
Di-n-butyl Phthalate	5100		20 U	20 U	20 U	20 U

Table 7 - Analytical Results for Sediment Samples; Harvest States and Peavey Grain

Sample ID Lab ID Sampling Date Sampling Depth Interval	LCRMA SL	LCRMA ML	HS-01-C1 K9806462-001 9/17/98 0 to 3 ft	HS01-C2 K9806462-002 9/17/98 3 to 5 ft	PG01-C1 K9806462-004 9/17/98 0 to 3 ft	PG01-C2 K9806462-005 9/17/98 3 to 5 ft
Di-n-octyl Phthalate	6200		20 U	20 U	20 U	20 U
Diethyl Phthalate	1200		20 U	20 U	20 U	20 U
Dimethyl Phthalate	1400		20 U	20 U	20 U	20 U
Semivolatiles in µg/kg						
Benzoic Acid	650	760	100 U	100 U	100 U	100 U
Benzyl Alcohol	57	870	6 U	6 U	6 U	6 U
Dibenzofuran	540	1700	20 U	20 U	20 U	20 U
Hexachlorobenzene	22	230	20 U	20 U	20 U	20 U
Hexachlorobutadiene	29	290	20 U	20 U	20 U	20 U
N-Nitrosodiphenylamine	28	130	12 U	12 U	12 U	12 U
Volatiles in µg/kg						
1,2-Dichlorobenzene	35	110	1 U	1 U	1 U	1 U
1,3-Dichlorobenzene	170		1 U	1 U	1 U	1 U
1,4-Dichlorobenzene	110	120	1 U	1 U	1 U	1 U
Pesticide/PCBs in µg/kg						
4,4'-DDD			3.3 U	3.3 U	3.3 U	3.3 U
4,4'-DDE			2.3 U	2.3 U	2.3 U	2.3 U
4,4'-DDT			6.7 U	6.7 U	6.7 U	6.7 U
Total DDT	6.9	69	6.7 U	6.7 U	6.7 U	6.7 U
Aldrin	10		1.7 U	1.7 U	1.7 U	1.7 U
Aroclor 1016			10 U	10 U	10 U	10 U
Aroclor 1221			10 U	10 U	10 U	10 U
Aroclor 1232			10 U	10 U	10 U	10 U
Aroclor 1242			10 U	10 U	10 U	10 U
Aroclor 1248			10 U	10 U	10 U	10 U
Aroclor 1254			10 U	10 U	10 U	10 U
Aroclor 1260			10 U	10 U	10 U	10 U
Total PCBs	130	3100	10 U	10 U	10 U	10 U
Chlordane	10		2 U	2 U	2 U	2 U
Dieldrin	10		2.3 U	2.3 U	2.3 U	2.3 U
Endosulfan I						
Endosulfan II						
Endosulfan Sulfate						
Endrin						
Endrin Aldehyde						
Endrin Ketone						
Heptachlor	10		1.7 U	1.7 U	1.7 U	1.7 U
Heptachlor Epoxide						
Methoxychlor						
Toxaphene						
alpha-BHC						
alpha-Chlordane						
beta-BHC						
delta-BHC						
gamma-BHC (Lindane)	10		1.7 U	1.7 U	1.7 U	1.7 U
gamma-Chlordane						

Notes: Exceeds LCRMA SL

SQLs Exceeds LCRMA SL

Table 8 - Analytical Results for Sediment Samples; Longview Grain

Sample ID Lab ID Sampling Date Sampling Depth Interval	LCRMA SL	LCRMA ML	LG01-C1 K9806462-007 9/15/98 0 to 3 ft	LG01-C2 K9806462-008 9/15/98 3 to 5 ft
Conventionals				
Ammonia as Nitrogen			24.1	2.6
Carbon, Total Organic (TOC)			0.3	0.05 U
Solids, Total			68	75.3
Solids, Total Volatile			1.58	0.64
Sulfide, Total			5.93	0.71
Metals in mg/kg				
Antimony, Total	150	200	0.04 UJ/J	0.04 UJ/J
Arsenic, Total	57	700	0.5 J	0.2 J
Cadmium, Total	5.1	14	0.1	0.07
Chromium, Total			3.8	2.1
Copper, Total	390	1300	14.9	9.4
Lead, Total	450	1200	1.93	0.84
Mercury, Total	0.41	2.3	0.02 U	0.02 U
Nickel, Total	140	370	5.7	4.8
Silver, Total	6.1	8.4	0.04	0.02 J
Zinc, Total	410	3800	18	10
Organometallics in µg/L				
Tri-n-butyltin	0.15		0.02 UJ/J	
LPAHs in µg/kg				
Acenaphthene	500	2000	20 U	20 U
Acenaphthylene	560	1300	20 U	20 U
Anthracene	960	13000	20 U	20 U
Fluorene	540	3600	20 U	20 U
Naphthalene	2100	2400	20 U	20 U
Phenanthrene	1500	21000	20 U	20 U
Total LPAHs	5200	29000	20 U	20 U
HPAHs in µg/kg				
Benz(a)anthracene	1300	5100	20 U	20 U
Benzo(a)pyrene	1600	3600	20 U	20 U
Benzo(b)fluoranthene			20 U	20 U
Benzo(g,h,i)perylene	670	3200	20 U	20 U
Benzo(k)fluoranthene			20 U	20 U
Chrysene	1400	21000	20 U	20 U
Dibenz(a,h)anthracene	230	1900	20 U	20 U
Fluoranthene	1700	30000	36	20 U
Indeno(1,2,3-cd)pyrene	600	16000	20 U	20 U
Pyrene	2600	16000	24	20 U
Total Benzofluoranthenes	3200	9900	20 U	20 U
Total HPAHs	12000	69000	60	20 U
Phenols in µg/kg				
2,4-Dimethylphenol	29	210	6 U	6 U
2-Methylphenol	63	77	6 U	6 U
4-Methylphenol	670	3600	20 U	20 U
Pentachlorophenol (PCP)	400	690	61 U	61 U
Phenol	420	1200	20 U	20 U
Phthalates in µg/kg				
Bis(2-ethylhexyl) Phthalate	8300		20 U	20 U
Butyl Benzyl Phthalate	970		20 U	20 U
Di-n-butyl Phthalate	5100		20 U	20 U

Table 8 - Analytical Results for Sediment Samples; Longview Grain

Sample ID Lab ID Sampling Date Sampling Depth Interval	LCRMA SL	LCRMA ML	LG01-C1 K9806462-007 9/15/98 0 to 3 ft	LG01-C2 K9806462-008 9/15/98 3 to 5 ft
Di-n-octyl Phthalate	6200		20 U	20 U
Diethyl Phthalate	1200		20 U	20 U
Dimethyl Phthalate	1400		20 U	20 U
Semivolatiles in µg/kg				
Benzoic Acid	650	760	100 U	100 U
Benzyl Alcohol	57	870	6 U	6 U
Dibenzofuran	540	1700	20 U	20 U
Hexachlorobenzene	22	230	20 U	20 U
Hexachlorobutadiene	29	290	20 U	20 U
N-Nitrosodiphenylamine	28	130	12 U	12 U
Volatiles in µg/kg				
1,2-Dichlorobenzene	35	110	1 U	1 U
1,3-Dichlorobenzene	170		1 U	1 U
1,4-Dichlorobenzene	110	120	1 U	1 U
Pesticide/PCBs in µg/kg				
4,4'-DDD			3.3 U	3.3 U
4,4'-DDE			2.3 U	2.3 U
4,4'-DDT			6.7 U	6.7 U
Total DDT	6.9	69	6.7 U	6.7 U
Aldrin	10		1.7 U	1.7 U
Aroclor 1016			10 U	10 U
Aroclor 1221			10 U	10 U
Aroclor 1232			10 U	10 U
Aroclor 1242			10 U	10 U
Aroclor 1248			10 U	10 U
Aroclor 1254			10 U	10 U
Aroclor 1260			10 U	10 U
Total PCBs	130	3100	10 U	10 U
Chlordane	10		2 U	2 U
Dieldrin	10		2.3 U	2.3 U
Endosulfan I				
Endosulfan II				
Endosulfan Sulfate				
Endrin				
Endrin Aldehyde				
Endrin Ketone				
Heptachlor	10		1.7 U	1.7 U
Heptachlor Epoxide				
Methoxychlor				
Toxaphene				
alpha-BHC				
alpha-Chlordane				
beta-BHC				
delta-BHC				
gamma-BHC (Lindane)	10		1.7 U	1.7 U
gamma-Chlordane				

Notes: [solid box] Exceeds LCRMA SL

[dotted box] SQLs Exceeds LCRMA SL

Table 9 - Analytical Results for Sediment Samples; Willamette River Surface Sediment Samples

Sample ID			Grab 1	Grab 2	Grab 3	Grab 4
Lab ID			K9806351-001	K9806351-002	K9806351-003	K9806351-004
Sampling Date	LCRMA	LCRMA	9/14/98	9/14/98	9/14/98	9/14/98
Sampling Depth Interval	SL	ML	0 to 10 cm	0 to 10 cm	0 to 10 cm	0 to 10 cm
Conventionals						
Ammonia as Nitrogen			161	83.7	29.5	128
Carbon, Total Organic (TOC)			1.98	1.38	1.03	2.27
Solids, Total			44	50.7	57.5	38.6
Solids, Total Volatile			8.5	8.31	4.97	9.01
Sulfide, Total			56	100	52	7
Metals in mg/kg						
Antimony, Total	150	200	0.02 U	0.02	0.02 U	0.02
Arsenic, Total	57	700	1.8	1.8	1.8	1.8
Cadmium, Total	5.1	14	0.27 J	0.22 J	0.16 J	0.2 J
Chromium, Total			19.5	17.7	14.3	21.2
Copper, Total	390	1300	26.2	22.7	18.3	26.2
Lead, Total	450	1200	17.7	13.9	9.58	17.7
Mercury, Total	0.41	2.3	0.07	0.05	0.03 J	0.07
Nickel, Total	140	370	15.8	16.1	15.2	16.3
Silver, Total	6.1	8.4	0.2	0.2	0.16	0.24
Zinc, Total	410	3800	70.1	66	52.3	67.9
Organometallics in μg/L						
Tri-n-butyltin	0.15		0.05	0.05	0.02 U	0.02 U
LPAHs in μg/kg						
Acenaphthene	500	2000	20 U	26	20 U	250
Acenaphthylene	560	1300	20 U	21	20 U	90
Anthracene	960	13000	32	33	25	310
Fluorene	540	3600	20 U	20 U	20	180
Naphthalene	2100	2400	20 U	20 U	20 U	160
Phenanthrene	1500	21000	130	100	88	1200
Total LPAHs	5200	29000	162	180	133	2190
HPAHs in μg/kg						
Benz(a)anthracene	1300	5100	180	210	81	1200
Benzo(a)pyrene	1600	3600	230	290	110	1500
Benzo(b)fluoranthene			210	220	89	1100
Benzo(g,h,i)perylene	670	3200	150	150	72	620
Benzo(k)fluoranthene			150	160	69	920
Chrysene	1400	21000	190	210	94	1200
Dibenz(a,h)anthracene	230	1900	51	40	20 U	140
Fluoranthene	1700	30000	350	380	200	$\boxed{2600}$
Indeno(1,2,3-cd)pyrene	600	16000	220	220	100	$\boxed{980}$
Pyrene	2600	16000	330	430	250	$\boxed{3000}$
Total Benzofluoranthenes	3200	9900	360	380	158	2020
Total HPAHs	12000	69000	2061	2310	1065	$\boxed{13260}$
Phenols in μg/kg						
2,4-Dimethylphenol	29	210	6 U	6 U	6 U	6 U
2-Methylphenol	63	77	6 U	6 U	6 U	6 U
4-Methylphenol	670	3600	20 U	20 U	20 U	20 U
Pentachlorophenol (PCP)	400	690	61 U	61 U	61 U	61 U
Phenol	420	1200	20 U	20 U	20 U	20 U
Phthalates in μg/kg						
Bis(2-ethylhexyl) Phthalate	8300		400	280	200	470
Butyl Benzyl Phthalate	970		21	25	26	55
Di-n-butyl Phthalate	5100		20 U	20 U	20 U	20 U

Table 9 - Analytical Results for Sediment Samples; Willamette River Surface Sediment Samples

Sample ID / Lab ID / Sampling Date / Sampling Depth Interval	LCRMA SL	LCRMA ML	Grab 1 K9806351-001 9/14/98 0 to 10 cm	Grab 2 K9806351-002 9/14/98 0 to 10 cm	Grab 3 K9806351-003 9/14/98 0 to 10 cm	Grab 4 K9806351-004 9/14/98 0 to 10 cm
Di-n-octyl Phthalate	6200		20 U	20 U	20 U	20 U
Diethyl Phthalate	1200		20 U	20 U	20 U	20 U
Dimethyl Phthalate	1400		20 U	20 U	20 U	20 U
Semivolatiles in µg/kg						
Benzoic Acid	650	760	100 U	100 U	100 U	100
Benzyl Alcohol	57	870	12	6 U	6 U	15
Dibenzofuran	540	1700	20 U	20 U	20 U	45
Hexachlorobenzene	22	230	20 U	20 U	20 U	20 U
Hexachlorobutadiene	29	290	20 U	20 U	20 U	20 U
N-Nitrosodiphenylamine	28	130	12 U	12 U	12 U	12 U
Volatiles in µg/kg						
1,2-Dichlorobenzene	35	110	1 U	1 U	1 U	1 U
1,3-Dichlorobenzene	170		1 U	1 U	1 U	1 U
1,4-Dichlorobenzene	110	120	1 U	1 U	1 U	1 U
Pesticide/PCBs in µg/kg						
4,4'-DDD			3.3 U	3.3 U	3.3 U	11
4,4'-DDE			3.5	2.5	2.3 U	5.9
4,4'-DDT			6.7 U	13	6.7 U	49
Total DDT	6.9	69	3.5	15.5	6.7 U	65.9
Aldrin	10		1.7 U	1.7 U	1.7 U	2.2
Aroclor 1016			10 U	10 U	10 U	10 U
Aroclor 1221			10 U	10 U	10 U	10 U
Aroclor 1232			10 U	10 U	10 U	10 U
Aroclor 1242			10 U	10 U	10 U	10 U
Aroclor 1248			10 U	10 U	10 U	10 U
Aroclor 1254			10 U	10 U	10 U	10 U
Aroclor 1260			13	10 U	10 U	15 U
Total PCBs	130	3100	13	10 U	10 U	13
Chlordane	10					
Dieldrin	10		2.3 U	2.3 U	2.3 U	2.3 U
Endosulfan I						
Endosulfan II						
Endosulfan Sulfate						
Endrin						
Endrin Aldehyde						
Endrin Ketone						
Heptachlor	10		1.7 U	1.7 U	1.7 U	1.7 U
Heptachlor Epoxide						
Methoxychlor						
Toxaphene						
alpha-BHC						
alpha-Chlordane			1.7 U	1.7 U	1.7 U	1.7 U
beta-BHC						
delta-BHC						
gamma-BHC (Lindane)	10		1.7 U	1.7 U	1.7 U	1.7 U
gamma-Chlordane			1.7 U	1.7 U	1.7 U	1.7 U

Notes: [solid box] Exceeds LCRMA SL

[dotted box] SQLs Exceeds LCRMA SL

Table 9 - Analytical Results for Sediment Samples; Willamette River Surface Sediment Samples

Sample ID Lab ID Sampling Date Sampling Depth Interval	LCRMA SL	LCRMA ML	Grab 5 K9806351-005 9/14/98 0 to 10 cm	Grab 6 K9806351-006 9/14/98 0 to 10 cm	Grab 7 K9806351-007 9/14/98 0 to 10 cm	Grab 8 K9806351-008 9/14/98 0 to 10 cm
Conventionals						
Ammonia as Nitrogen			14.2	15.3	72.4	122
Carbon, Total Organic (TOC)			0.81	0.65	2.06	1.41
Solids, Total			71.7	76.6	53.3	40
Solids, Total Volatile			2.51	3.34	7.32	7.59
Sulfide, Total			6	1	7	90
Metals in mg/kg						
Antimony, Total	150	200	0.02 U	0.02 U	0.02 U	0.02
Arsenic, Total	57	700	1.3	0.7	1.3	1.4
Cadmium, Total	5.1	14	0.11 J	0.09 U	0.21 J	0.21 J
Chromium, Total			9.3	9.9	18.3	21.4
Copper, Total	390	1300	13.1	12.3	25.5	48
Lead, Total	450	1200	5.6	4.64	12.7	15.2
Mercury, Total	0.41	2.3	0.02 J	0.02 U	0.05	0.07
Nickel, Total	140	370	12.7	12.6	16.2	18.3
Silver, Total	6.1	8.4	0.12	0.08	0.18	0.3
Zinc, Total	410	3800	40	38.6	58.3	73.9
Organometallics in µg/L						
Tri-n-butyltin	0.15		0.02 U	0.02	0.07	0.12
LPAHs in µg/kg						
Acenaphthene	500	2000	31000	160	20 U	20 U
Acenaphthylene	560	1300	10000 U	100 U	20 U	20 U
Anthracene	960	13000	26000	340	20 U	20 U
Fluorene	540	3600	14000	140	20 U	20 U
Naphthalene	2100	2400	10000 U	100 U	20 U	20 U
Phenanthrene	1500	21000	84000	1300	23	33
Total LPAHs	5200	29000	155000	1940	23	33
HPAHs in µg/kg						
Benz(a)anthracene	1300	5100	39000	340	20	28
Benzo(a)pyrene	1600	3600	39000	340	22	29
Benzo(b)fluoranthene			19000	180	23	34
Benzo(g,h,i)perylene	670	3200	18000	170	20 U	20 U
Benzo(k)fluoranthene			21000	190	20 U	26
Chrysene	1400	21000	42000	360	26	36
Dibenz(a,h)anthracene	230	1900	10000 U	100 U	20 U	20 U
Fluoranthene	1700	30000	110000	1200	59	85
Indeno(1,2,3-cd)pyrene	600	16000	24000	230	20 U	23
Pyrene	2600	16000	140000	1400	62	83
Total Benzofluoranthenes	3200	9900	40000	370	23	60
Total HPAHs	12000	69000	452000	4410	212	344
Phenols in µg/kg						
2,4-Dimethylphenol	29	210	3000 U	30 U	6 U	6 U
2-Methylphenol	63	77	3000 U	30 U	6 U	6 U
4-Methylphenol	670	3600	10000 U	100 U	20 U	20 U
Pentachlorophenol (PCP)	400	690	30500 U	305 U	61 U	61 U
Phenol	420	1200	10000 U	100 U	20 U	20 U
Phthalates in µg/kg						
Bis(2-ethylhexyl) Phthalate	8300		10000 U	100 U	300	430
Butyl Benzyl Phthalate	970		10000 U	100 U	20 U	67
Di-n-butyl Phthalate	5100		10000 U	100 U	20 U	20 U

Table 9 - Analytical Results for Sediment Samples; Willamette River Surface Sediment Samples

Sample ID / Lab ID / Sampling Date / Sampling Depth Interval	LCRMA SL	LCRMA ML	Grab 5 K9806351-005 9/14/98 0 to 10 cm	Grab 6 K9806351-006 9/14/98 0 to 10 cm	Grab 7 K9806351-007 9/14/98 0 to 10 cm	Grab 8 K9806351-008 9/14/98 0 to 10 cm
Di-n-octyl Phthalate	6200		10000 U	100 U	20 U	25
Diethyl Phthalate	1200		10000 U	100 U	20 U	20 U
Dimethyl Phthalate	1400		10000 U	100 U	20 U	20 U
Semivolatiles in µg/kg						
Benzoic Acid	650	760	50000 U	500 U	100 U	100 U
Benzyl Alcohol	57	870	3000 U	30 U	6	9
Dibenzofuran	540	1700	10000 U	100 U	20 U	20 U
Hexachlorobenzene	22	230	10000 U	100 U	20 U	20 U
Hexachlorobutadiene	29	290	10000 U	100 U	20 U	20 U
N-Nitrosodiphenylamine	28	130	60000 U	60 U	12 U	12 U
Volatiles in µg/kg						
1,2-Dichlorobenzene	35	110	1 U	1 U	1 U	1 U
1,3-Dichlorobenzene	170		1 U	1 U	1 U	1 U
1,4-Dichlorobenzene	110	120	1 U	1 U	1 U	1 U
Pesticide/PCBs in µg/kg						
4,4'-DDD			14	3.3 U	3.3 U	3.3 U
4,4'-DDE			2.3 U	2.3 U	3.8	2.4
4,4'-DDT			11	6.7 U	6.7 U	6.7 U
Total DDT	6.9	69	25	6.7 U	3.8	2.4
Aldrin	10		1.7 U	1.7 U	1.7 U	1.7 U
Aroclor 1016			10 U	10 U	10 U	10 U
Aroclor 1221			10 U	10 U	10 U	10 U
Aroclor 1232			10 U	10 U	10 U	10 U
Aroclor 1242			10 U	10 U	10 U	10 U
Aroclor 1248			10 U	10 U	10 U	10 U
Aroclor 1254			10 U	10 U	10 U	10 U
Aroclor 1260			10 U	10 U	10 U	10 U
Total PCBs	130	3100	10 U	10 U	10 U	10 U
Chlordane	10					
Dieldrin	10		2.3 U	2.3 U	2.3 U	2.3 U
Endosulfan I						
Endosulfan II						
Endosulfan Sulfate						
Endrin						
Endrin Aldehyde						
Endrin Ketone						
Heptachlor	10		1.7 U	1.7 U	1.7 U	1.7 U
Heptachlor Epoxide						
Methoxychlor						
Toxaphene						
alpha-BHC						
alpha-Chlordane			1.7 U	1.7 U	1.7 U	1.7 U
beta-BHC						
delta-BHC						
gamma-BHC (Lindane)	10		1.7 U	1.7 U	1.7 U	2 U
gamma-Chlordane			1.7 U	1.7 U	1.7 U	1.7 U

Notes:
Exceeds LCRMA SL
Exceeds LCRMA ML
SQLs Exceeds LCRMA SL

Table 9 - Analytical Results for Sediment Sampels; Willamette River Surface Sediment Samples

Sample ID / Lab ID / Sampling Date / Sampling Depth Interval	LCRMA SL	LCRMA ML	Grab-9 K9806410-004 9/15/98 0 to 10 cm	Grab-10 K9806410-005 9/15/98 0 to 10 cm	Grab-11 K9806410-006 9/15/98 0 to 10 cm	Grab-12 K9806410-007 9/15/98 0 to 10 cm
Conventionals						
Ammonia as Nitrogen			106 UJ/J	88.1 UJ/J	167 UJ/J	96.6 UJ/J
Carbon, Total Organic (TOC)			1.58	1.57	2.24	1.23
Solids, Total						
Solids, Total Volatile						
Sulfide, Total			3	3	39	4
Metals in mg/kg						
Antimony, Total	150	200	0.15 UJ/J	0.15 UJ/J	0.16 UJ/J	0.22 UJ/J
Arsenic, Total	57	700	2.4	2	2.3	2.1
Cadmium, Total	5.1	14	0.14	0.17	0.19	0.15
Chromium, Total			20.1	20.1	22.3	18.3
Copper, Total	390	1300	21.6 UJ/J	22 UJ/J	25.6 UJ/J	20.5 UJ/J
Lead, Total	450	1200	14.5	14.8	13.2	13.6
Mercury, Total	0.41	2.3	0.06	0.06	0.07	0.05
Nickel, Total	140	370	16.8	17.1	18	16.8
Silver, Total	6.1	8.4	0.22	0.23	0.29	0.22
Zinc, Total	410	3800	63.7	63.2	64.1	63.2
Organometallics in µg/L						
Tri-n-butyltin	0.15		0.02 U	0.02 U	0.02 U	0.02 U
LPAHs in µg/kg						
Acenaphthene	500	2000	20 U	20 U	20 U	20 U
Acenaphthylene	560	1300	20 U	20 U	20 U	20 U
Anthracene	960	13000	20 U	20 U	20 U	20 U
Fluorene	540	3600	20 U	20 U	20 U	20 U
Naphthalene	2100	2400	20 U	20 U	20 U	20 U
Phenanthrene	1500	21000	26	20	48	25
Total LPAHs	5200	29000	26	20	48	25
HPAHs in µg/kg						
Benz(a)anthracene	1300	5100	26	27	28	25
Benzo(a)pyrene	1600	3600	28	36	22	28
Benzo(b)fluoranthene			29	32	24	27
Benzo(g,h,i)perylene	670	3200	20 U	22	20 U	20 U
Benzo(k)fluoranthene			21	24	20 U	20
Chrysene	1400	21000	31	32	27	31
Dibenz(a,h)anthracene	230	1900	20 U	20 U	20 U	20 U
Fluoranthene	1700	30000	67	59	85	65
Indeno(1,2,3-cd)pyrene	600	16000	23	29	20 U	23
Pyrene	2600	16000	68	62	75	72
Total Benzofluoranthenes	3200	9900	50	56	24	47
Total HPAHs	12000	69000	293	323	261	291
Phenols in µg/kg						
2,4-Dimethylphenol	29	210	6 U	6 U	6 U	6 U
2-Methylphenol	63	77	6 U	6 U	6 U	6 U
4-Methylphenol	670	3600	20 U	20 U	20 U	20 U
Pentachlorophenol (PCP)	400	690	61 U	61 U	61 U	61 U
Phenol	420	1200	20 U	20 U	20 U	20 U
Phthalates in µg/kg						
Bis(2-ethylhexyl) Phthalate	8300		410	320	440	1000
Butyl Benzyl Phthalate	970		38	48	22	33
Di-n-butyl Phthalate	5100		20 U	20 U	20 U	20 U

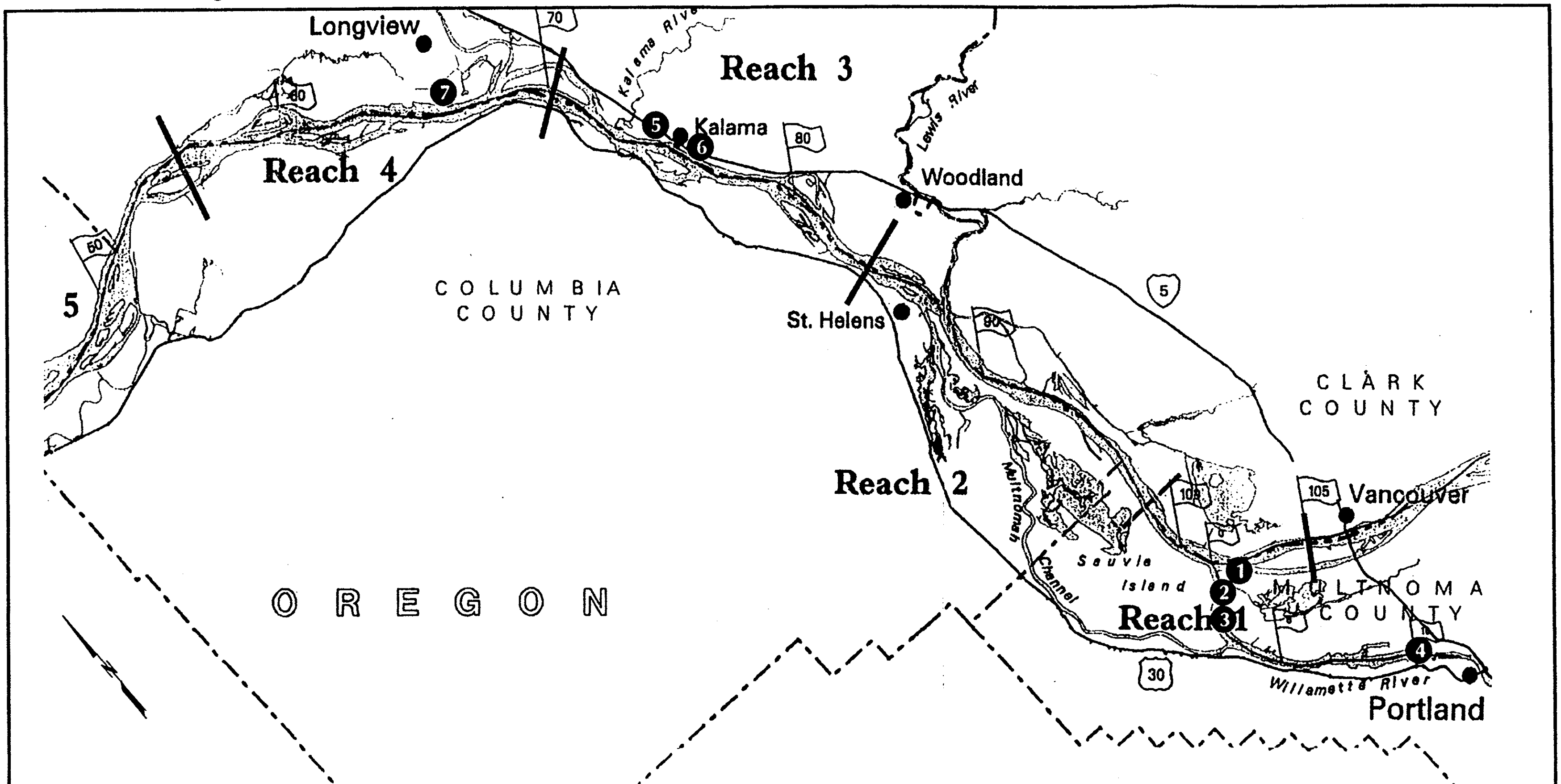
Table 9 - Analytical Results for Sediment Sampels; Willamette River Surface Sediment Samples

Sample ID Lab ID Sampling Date Sampling Depth Interval	LCRMA SL	LCRMA ML	Grab-9 K9806410-004 9/15/98 0 to 10 cm	Grab-10 K9806410-005 9/15/98 0 to 10 cm	Grab-11 K9806410-006 9/15/98 0 to 10 cm	Grab-12 K9806410-007 9/15/98 0 to 10 cm
Di-n-octyl Phthalate	6200		20 U	20 U	20 U	20 U
Diethyl Phthalate	1200		20 U	20 U	20 U	20 U
Dimethyl Phthalate	1400		20 U	20 U	20 U	20 U
Semivolatiles in µg/kg						
Benzoic Acid	650	760	100 U	100 U	100 U	100 U
Benzyl Alcohol	57	870	6 U	8	6 U	9
Dibenzofuran	540	1700	20 U	20 U	20 U	20 U
Hexachlorobenzene	22	230	20 U	20 U	20 U	20 U
Hexachlorobutadiene	29	290	20 U	20 U	20 U	20 U
N-Nitrosodiphenylamine	28	130	12 U	12 U	12 U	12 U
Volatiles in µg/kg						
1,2-Dichlorobenzene	35	110	1 U	1 U	1 U	1 U
1,3-Dichlorobenzene	170		1 U	1 U	1 U	1 U
1,4-Dichlorobenzene	110	120	1 U	1 U	1 U	1 U
Pesticide/PCBs in µg/kg						
4,4'-DDD			2 U	2 U	2 U	2 U
4,4'-DDE			2 U	2 U	3	2 U
4,4'-DDT			2 U	2 U	2 U	2 U
Total DDT	6.9	69	2 U	2 U	3	2 U
Aldrin	10		2 U	2 U	2 U	2 U
Aroclor 1016			10 U	10 U	10 U	10 U
Aroclor 1221			10 U	10 U	10 U	10 U
Aroclor 1232			10 U	10 U	10 U	10 U
Aroclor 1242			10 U	10 U	10 U	10 U
Aroclor 1248			10 U	10 U	10 U	10 U
Aroclor 1254			10 U	10 U	10 U	10 U
Aroclor 1260			10 U	14	10 U	14
Total PCBs	130	3100	10 U	14	10 U	14
Chlordane	10					
Dieldrin	10		2 U	2 U	2 U	2 U
Endosulfan I			2 U	2 U	2 U	2 U
Endosulfan II			2 U	2 U	2 U	2 U
Endosulfan Sulfate			2 U	2 U	2 U	2 U
Endrin			2 U	2 U	2 U	2 U
Endrin Aldehyde			2 U	2 U	2 U	2 U
Endrin Ketone			2 U	2 U	2 U	2 U
Heptachlor	10		2 U	2 U	2 U	2 U
Heptachlor Epoxide			2 U	2 U	2 U	2 U
Methoxychlor			4 U	4 U	4 U	4 U
Toxaphene			40 U	60 U	70 U	70 U
alpha-BHC			2 U	2 U	2 U	2 U
alpha-Chlordane			2 U	2 U	2 U	2 U
beta-BHC			2 U	2 U	2 U	2 U
delta-BHC			2 U	2 U	2 U	2 U
gamma-BHC (Lindane)	10		2 U	2 U	2 U	2 U
gamma-Chlordane			2 U	2 U	2 U	2 U

Notes: [box] Exceeds LCRMA SL

[dotted box] SQLs Exceeds LCRMA SL

General Location of Sampling Areas
Columbia River Navigation Channel



Note: Base map prepared from "Columbia River Dredged Material Management Study Overview Map".

Study Sites:

	Site	Port Facility	River
1	Terminal 6	Port of Portland	Columbia
2	Berth 501	Port of Portland	Willamette
3	Berth 401	Port of Portland	Willamette
4	Irving Street Terminal	Port of Portland	Willamette
5	Peavey Grain Terminal	Port of Kalama	Willamette
6	Harvest States Grain Terminal	Port of Kalama	
7	Longview Grain Wharf	Port of Longview	Columbia

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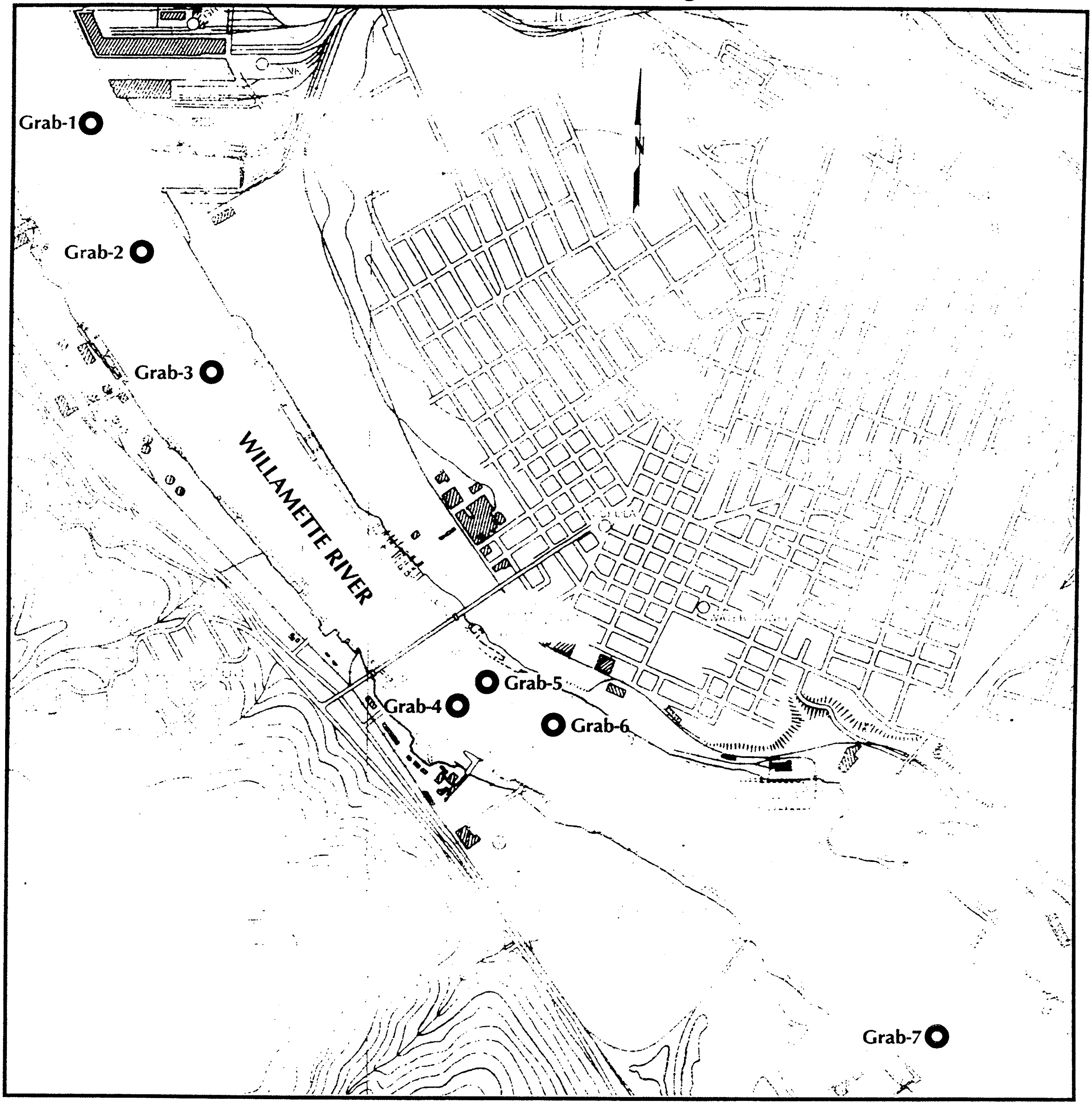
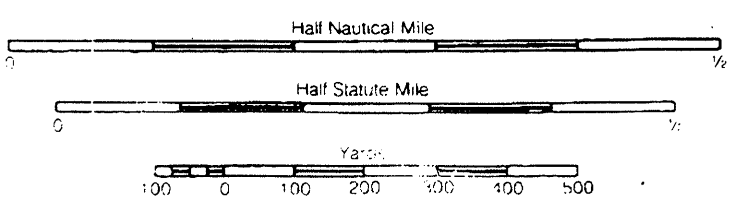
Figure 1

General Location of Sampling Areas

Surface Sediments, Willamette River, Portland, Oregon



Note: Base map prepared from a Port of Portland map dated 4/98.



Legend:

Grab-3 O Approximate Grab Sample Location and Designation

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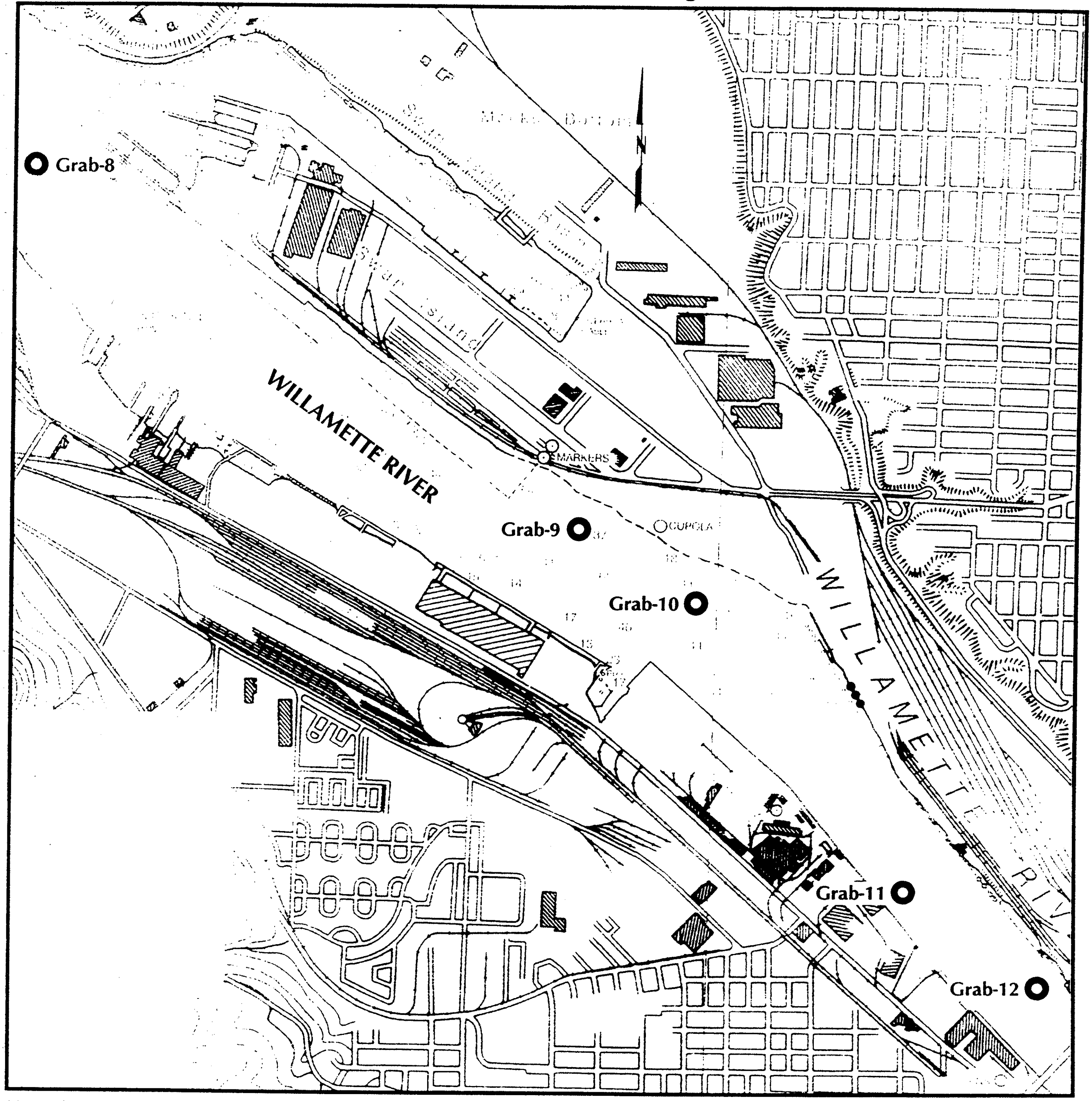
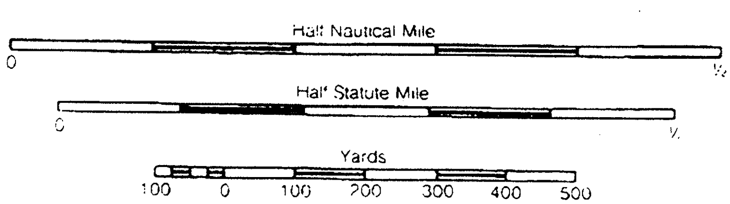
Figure 2

General Location of Sampling Areas

Surface Sediments, Willamette River, Portland, Oregon



Note: Base map prepared from a Port of Portland map dated 4/98.



Legend:

Grab-8 ○ Approximate Grab Sample Location and Designation

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Figure 3

APPENDIX A
CHEMICAL DATA QUALITY REVIEW

In total, 34 sediment samples, including two field duplicates, were collected between September 14, 1998 and September 17, 1998. The samples were submitted to Columbia Analytical Services, Kelso, Washington for analysis of the following:

- Total Metals (EPA Method 200.8/7471A);
- Semivolatile Organics (GC/MS SIM);
- Volatile Organics (EPA Method 8260B);
- Pesticides/PCBs (EPA Method 8081/8082);
- Tributyltin (TBT, GC/FPD);
- Total Organic Carbon (ASTM D4129-82M);
- Ammonia (EPA Method 350.1M);
- Sulfide (PSEP);
- Total Volatile Solids (EPA Method 160.4M); and
- Total Solids (EPA Method 160.3).

The following criteria were evaluated in the standard data quality review process for the results:

- Holding times;
- Method blanks;
- Reporting Limits;
- Surrogate recoveries;
- Blank spike and laboratory control sample (LCS) recoveries;
- Matrix spike/matrix spike duplicate (MS/MSD) recoveries; and
- Laboratory duplicates relative percent differences (RPDs).

Total Metals. All required holding times were met. Chromium, lead, nickel, silver, and zinc were detected below detection limits in method blanks. No qualifiers were assigned since sample concentrations were greater than five times blank contaminations. Cadmium was detected above detection limit in one method blank. Sample GRAB 6 was qualified as not detected (U). Reporting limits were elevated due to sample dilution. LCS recoveries were within laboratory control limits. The MS recoveries of antimony and copper were below laboratory control limits. Associated sample results were qualified as estimated (UJ/J). Laboratory duplicate RPDs were acceptable.

Semivolatile Organics. All required holding times were met. No method blank contamination was detected. Reporting limits were elevated due to sample dilution. Surrogate recoveries of 2-fluorophenol and 2,4,6-tribromophenol in the acid fraction were below laboratory control limits in method blanks, QC samples, and several project samples. Samples were reextracted and reanalyzed outside holding time by 42 to 45 days. Since reextraction grossly exceeded holding time criteria and demonstrated surrogates outside control limits were due to matrix interference, initial sample results were used. LCS and MS/MSD recoveries were within laboratory control limits.

Volatile Organics. All required holding times were met. No method blank contamination was detected. Reporting limits were elevated due to low percent solids in samples. Surrogate, LCS, and MS/MSD recoveries were within laboratory control limits.

Pesticides/PCBs. All required holding times were met. No method blank contamination was detected. Reporting limits were elevated due to matrix interference. Surrogate, LCS, and MS/MSD recoveries were within laboratory control limits.

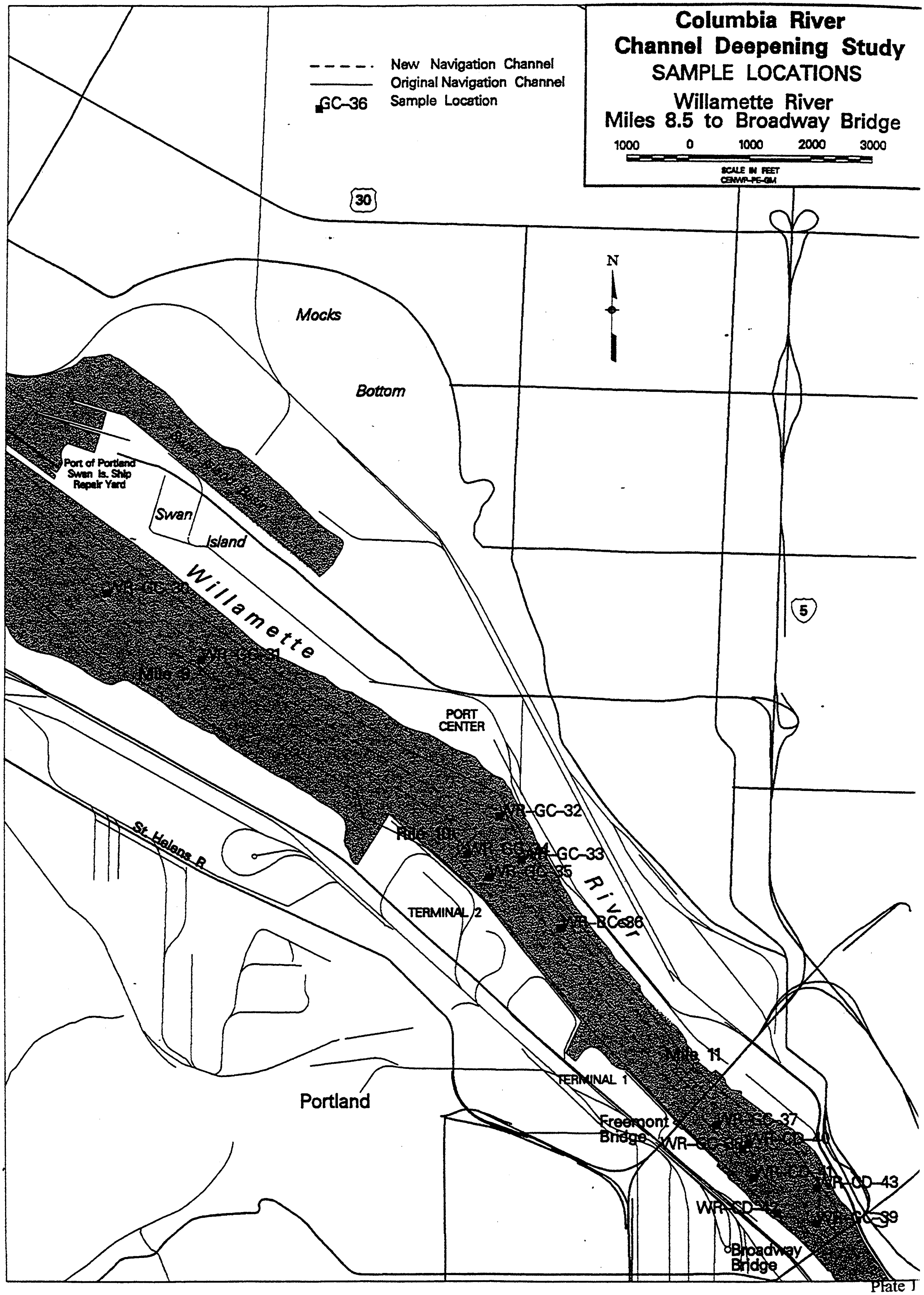
Tributyltin. All required holding times were met. No method blank contamination was detected. Reporting limits were elevated due to insufficient sample provided for analysis. Surrogate recoveries of tri-n-propyltin were below laboratory control limits in method blank, QC sample, and several project samples. Samples HS-01-C1, PG-01-C1, and LG-01-C1 were qualified as estimated (UJ/J). LCS recoveries were acceptable. MS/MSD recoveries were below laboratory control limits due to severe emulsions during extraction. No qualifiers were assigned since LCS recoveries were acceptable.

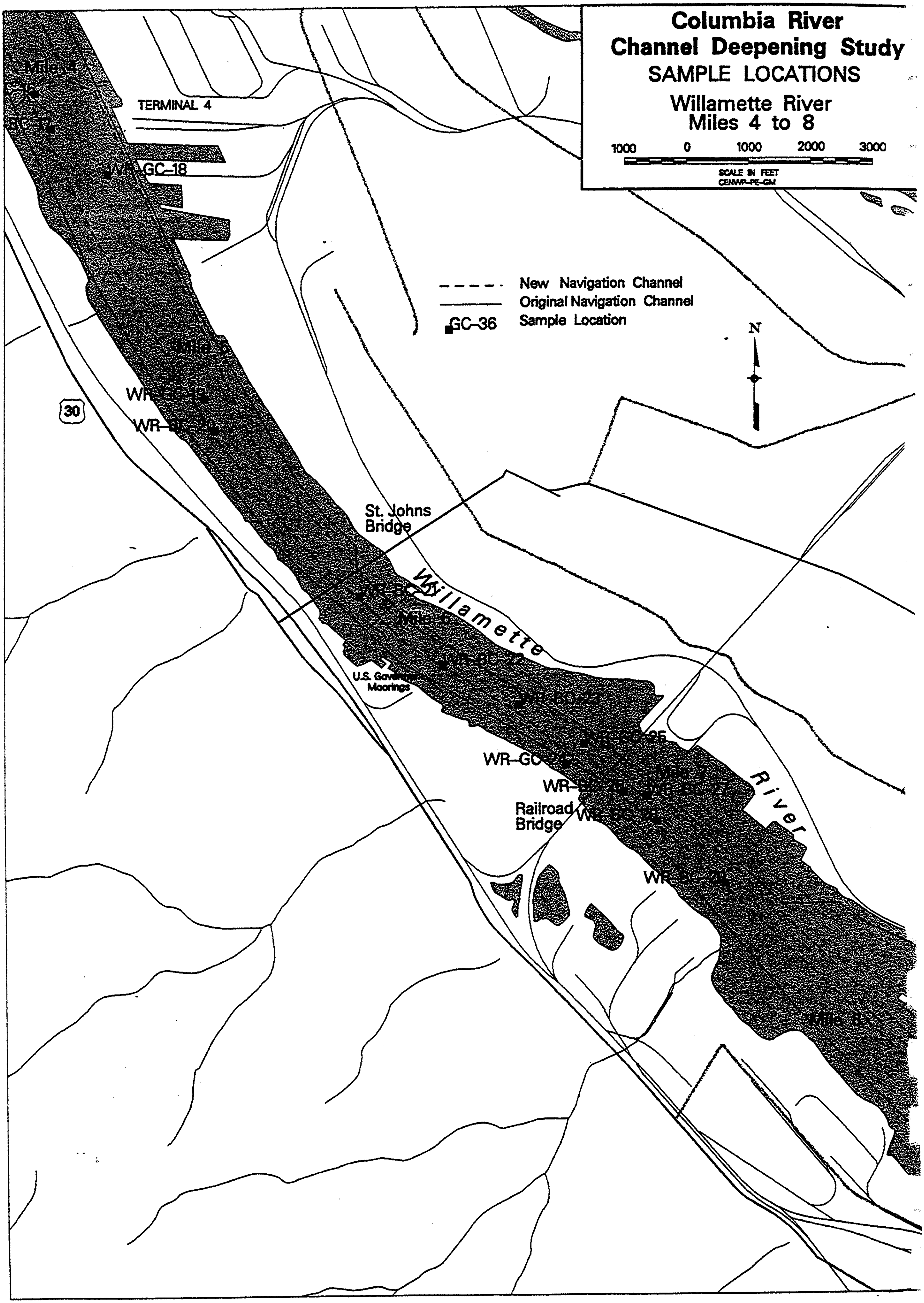
Total Organic Carbon. All required holding times were met. No method blank contamination was detected. LCS and MS recoveries were acceptable. Laboratory duplicate RPD was within control limits.

Ammonia/Sulfide. All required holding times were met. No method blank contamination was detected. LCS and MS recoveries were within control limits. Laboratory duplicate RPD for ammonia was above laboratory control limits. Associated sample results in accession K9806410 were qualified as estimated (UJ/J).

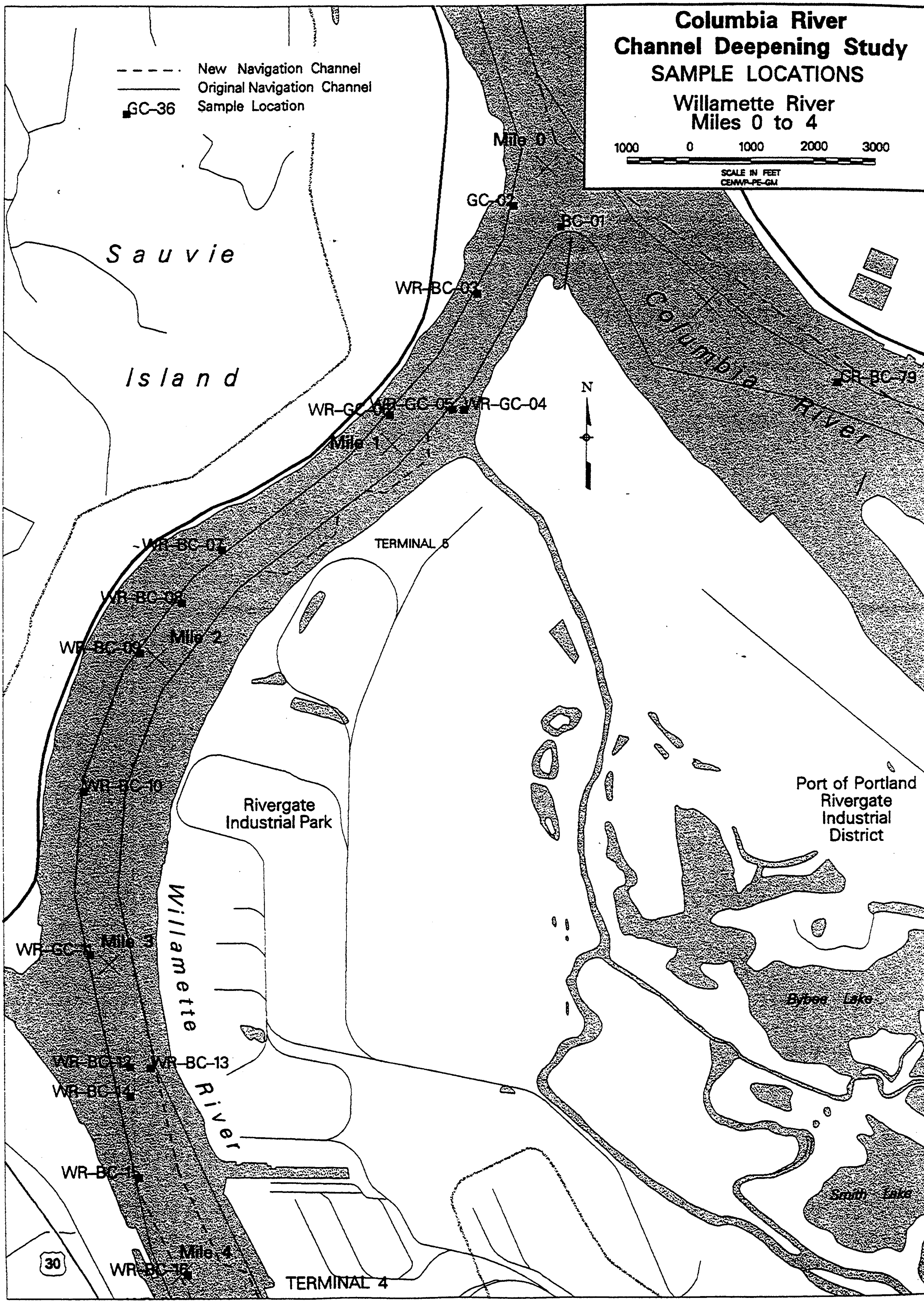
Total Volatile Solids/Total Solids. All required holding times were met. No method blank contamination was detected. Laboratory duplicate RPDs were within control limits.

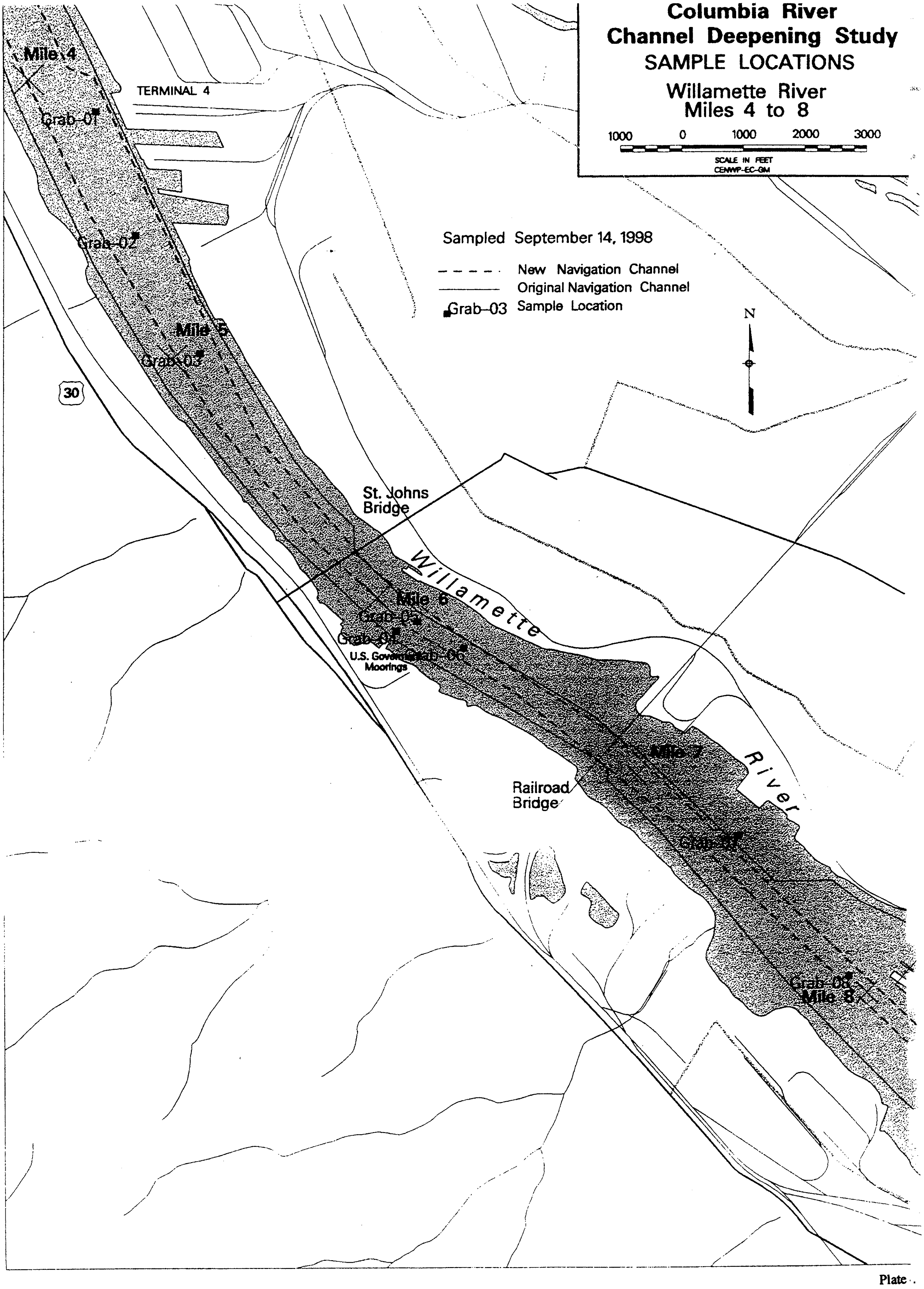
PLATES

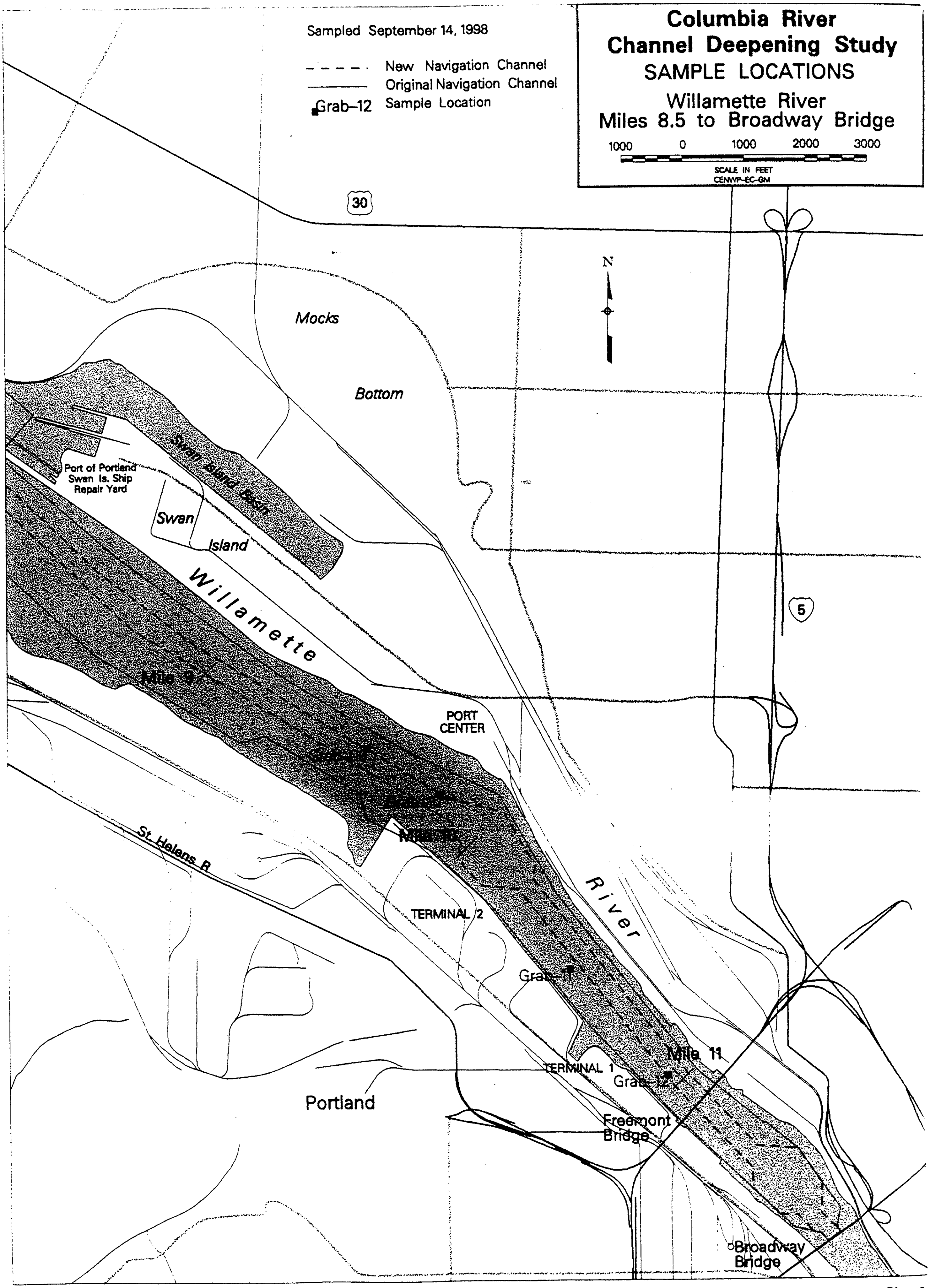

Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Willamette River
Miles 8.5 to Broadway Bridge
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
New Navigation Channel
Original Navigation Channel
GC-36 Sample Location
30
N
Mocks
Bottom
Port of Portland
Swan Is. Ship
Repair Yard
Swan
Island
Willamette
River
5
PORT
CENTER
WR-GC-32
GC-33
St Helens R
TERMINAL 2
TERMINAL 1
Mile 11
Portland
Freemont
Bridge
Broadway
Bridge
Plate 1



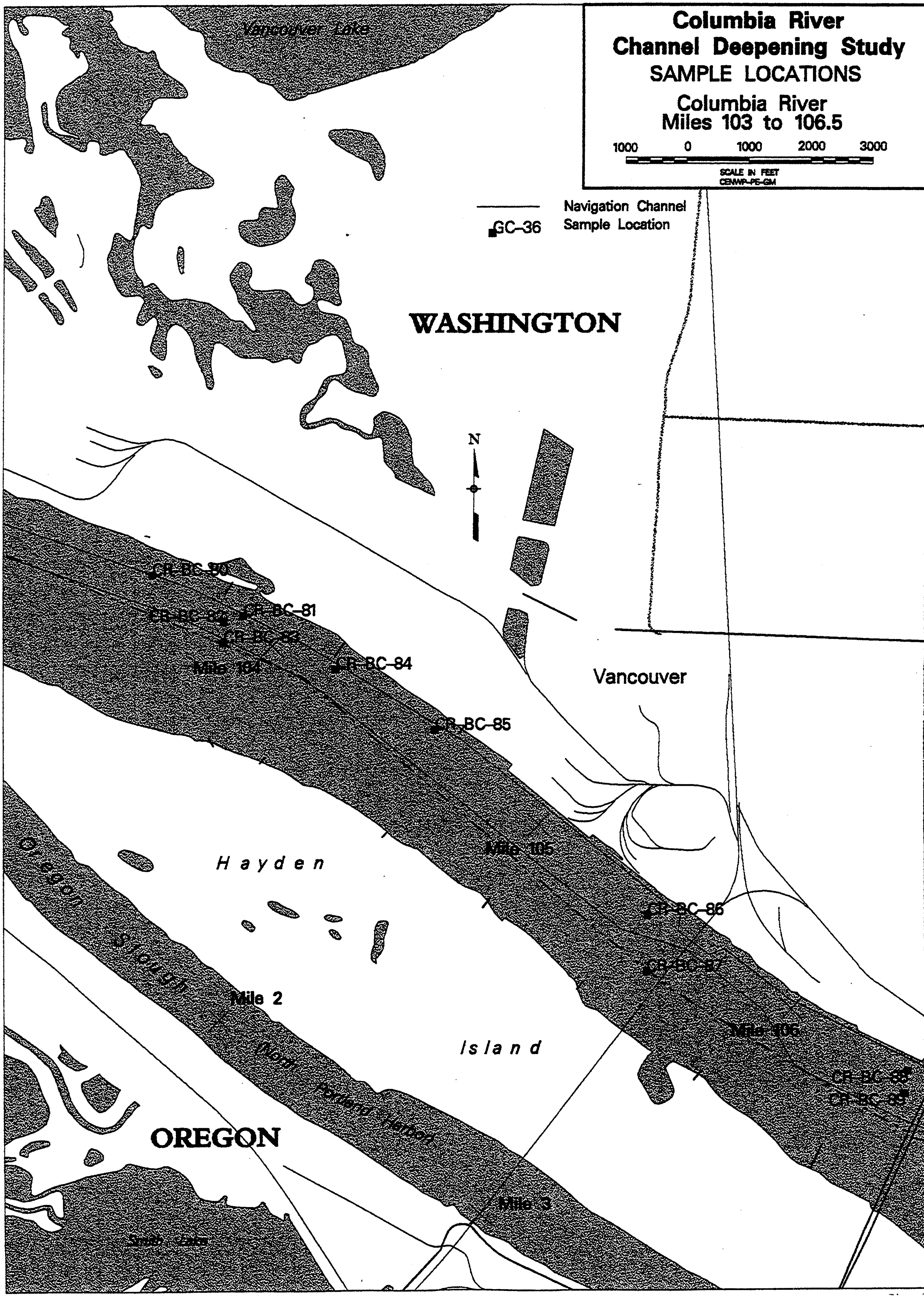
Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Willamette River
Miles 4 to 8
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
New Navigation Channel
Original Navigation Channel
GC-36 Sample Location
N
TERMINAL 4
WR-GC-18
30
St. Johns Bridge
Willamette
River
Railroad Bridge
Moorings
Mile 8

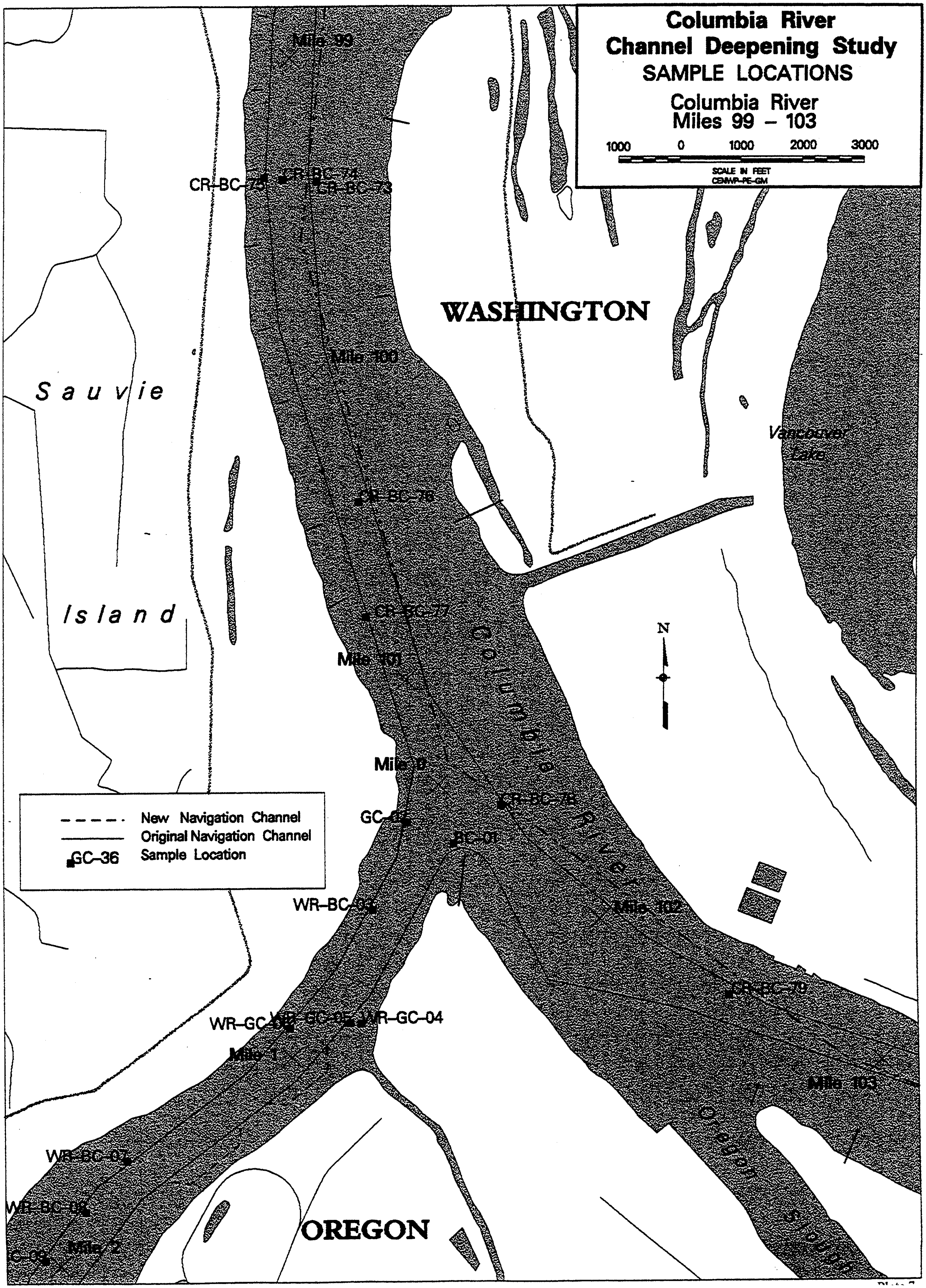

Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Willamette River
Miles 0 to 4
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
New Navigation Channel
Original Navigation Channel
GC-36 Sample Location
Sauvie
Island
Mile 0
GC-02
BC-01
WR-BC-03
Columbia River
CR-BC-79
N
WR-GC-06
WR-GC-05
WR-GC-04
Mile 1
TERMINAL 5
WR-BC-07
WR-BC-08
Mile 2
WR-BC-09
WR-BC-10
Rivergate
Industrial Park
Port of Portland
Rivergate
Industrial
District
Willamette River
WR-GC-11
Mile 3
Bybee Lake
WR-BC-12
WR-BC-13
WR-BC-14
WR-BC-15
Smith Lake
30
Mile 4
WR-BC-16
TERMINAL 4


Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Willamette River
Miles 4 to 8
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-EC-GM
Sampled September 14, 1998
New Navigation Channel
Original Navigation Channel
Grab–03 Sample Location
N
Mile 4
TERMINAL 4
Grab-01
Grab-02
Mile 5
Grab-03
30
St. Johns
Bridge
Willamette
River
Mile 6
Grab-05
Grab-04
Grab-06
U.S. Government
Moorings
Mile 7
Railroad
Bridge
Grab-07
Grab-08
Mile 8

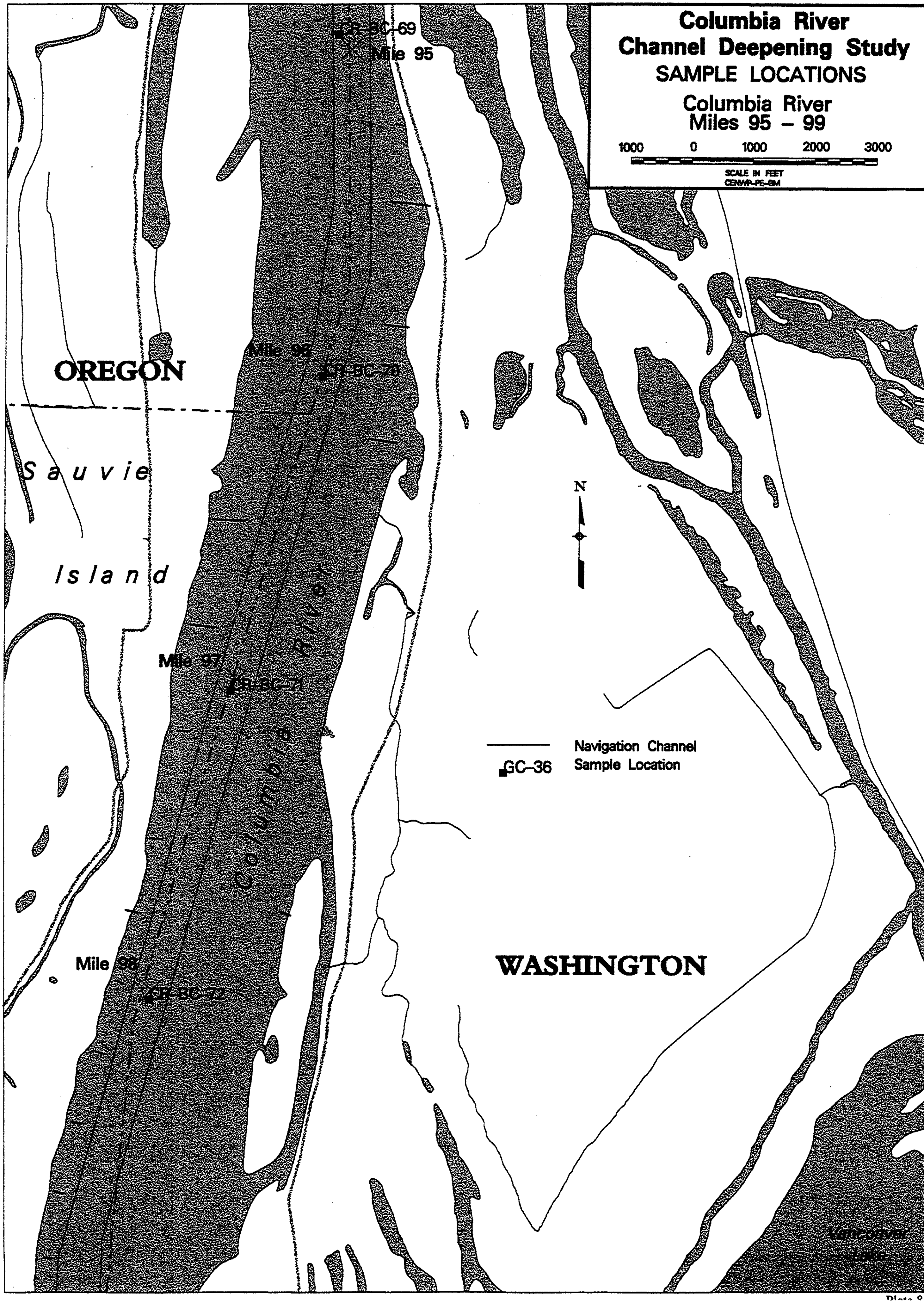


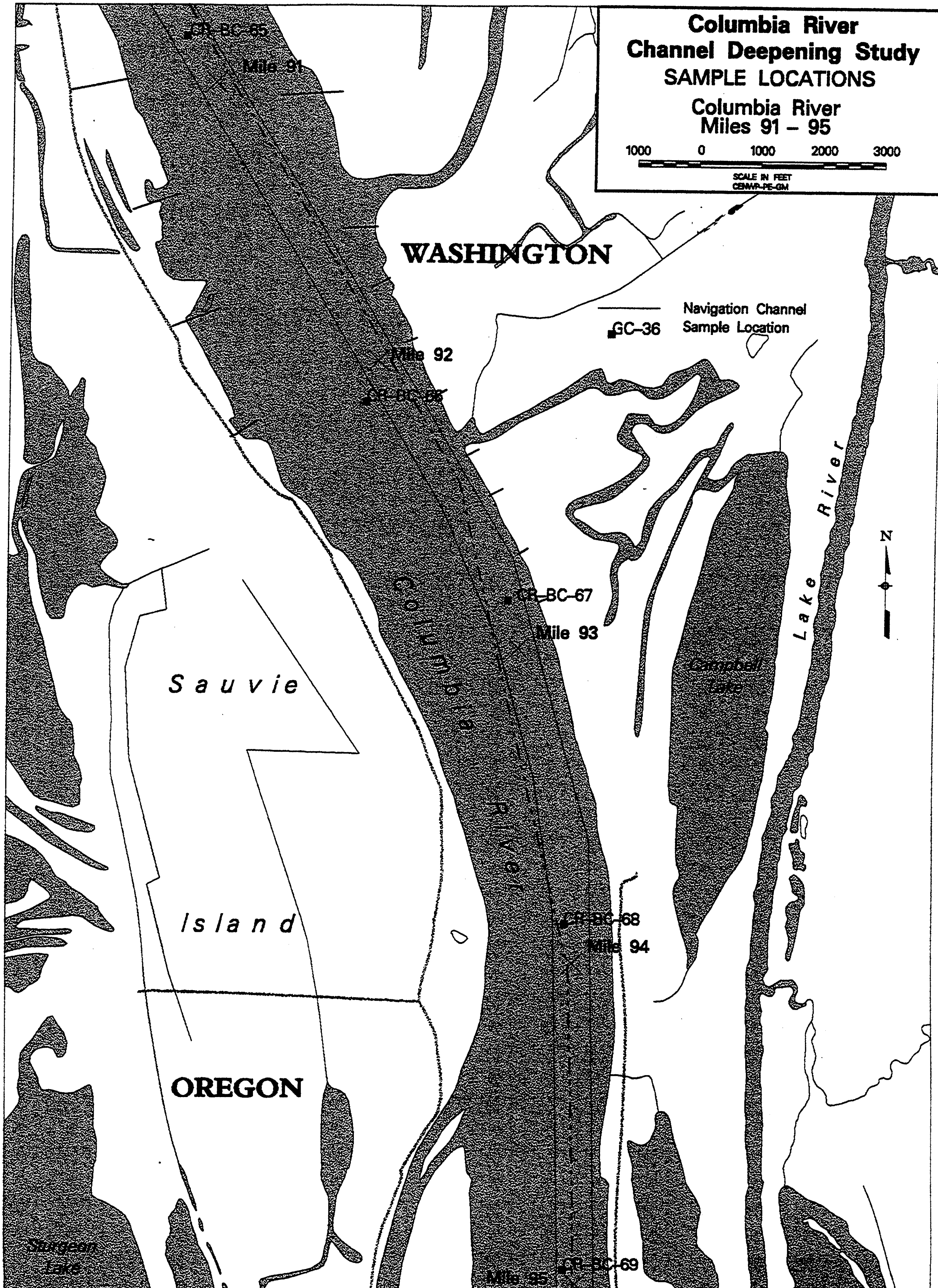
Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Willamette River
Miles 8.5 to Broadway Bridge
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-EC-GM
Sampled September 14, 1998
New Navigation Channel
Original Navigation Channel
Grab-12 Sample Location
30
N
Mocks
Bottom
Swan Island Basin
Port of Portland Swan Is. Ship Repair Yard
Swan
Island
Willamette
River
Mile 9
PORT CENTER
Mile 10
St. Helens R
TERMINAL 2
Grab-11
5
Mile 11
TERMINAL 1
Grab-12
Freemont Bridge
Portland
Broadway Bridge

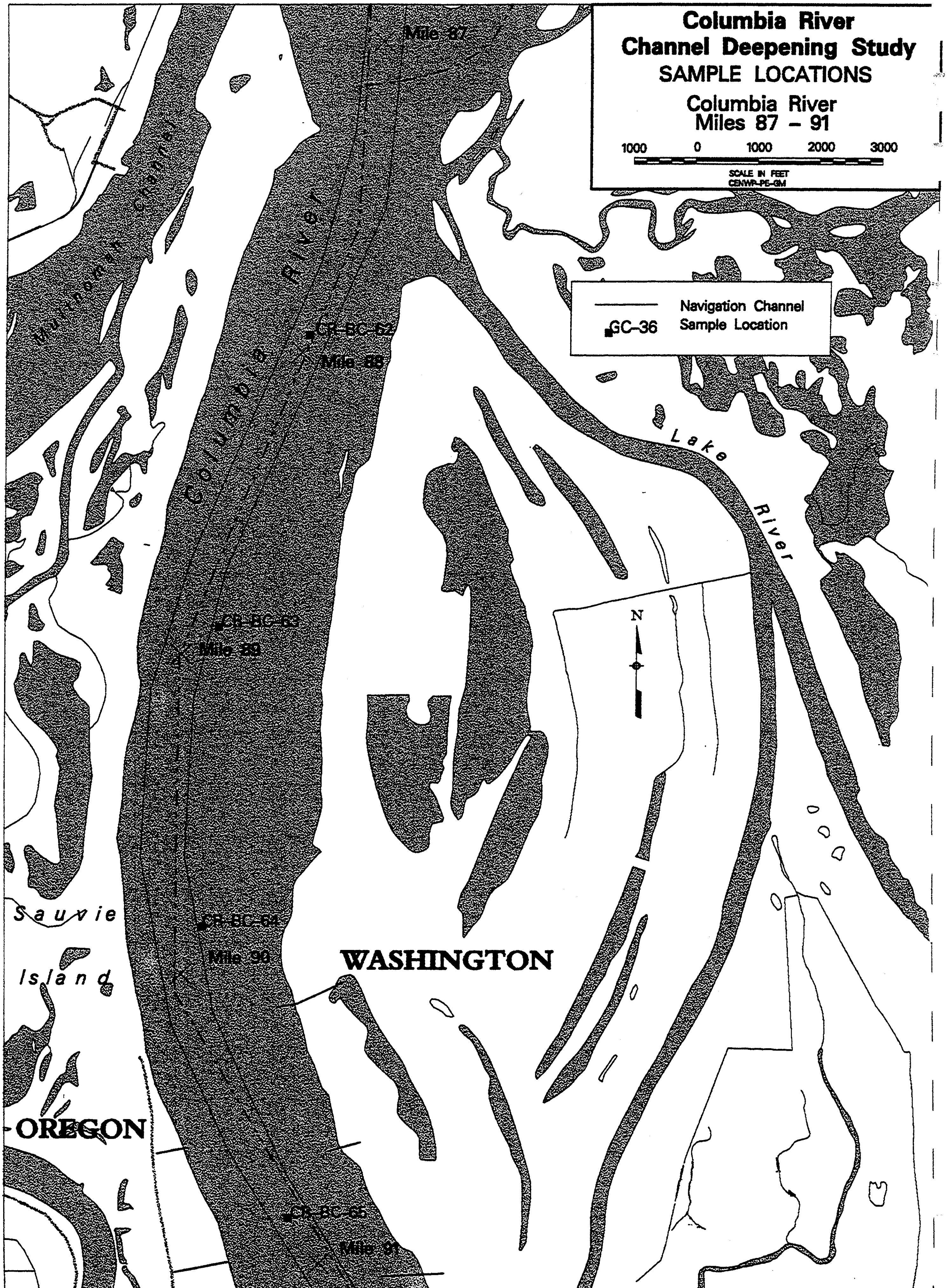

Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 103 to 106.5
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
GC-36 Sample Location
Vancouver Lake
WASHINGTON
N
CR-BC-80
CR-BC-81
CR-BC-82
CR-BC-83
CR-BC-84
Mile 104
CR-BC-85
Vancouver
Mile 105
Hayden
Island
CR-BC-86
CR-BC-87
Mile 106
CR-BC-88
CR-BC-89
Oregon Slough
Mile 2
North Portland Harbor
OREGON
Mile 3
Smith Lake



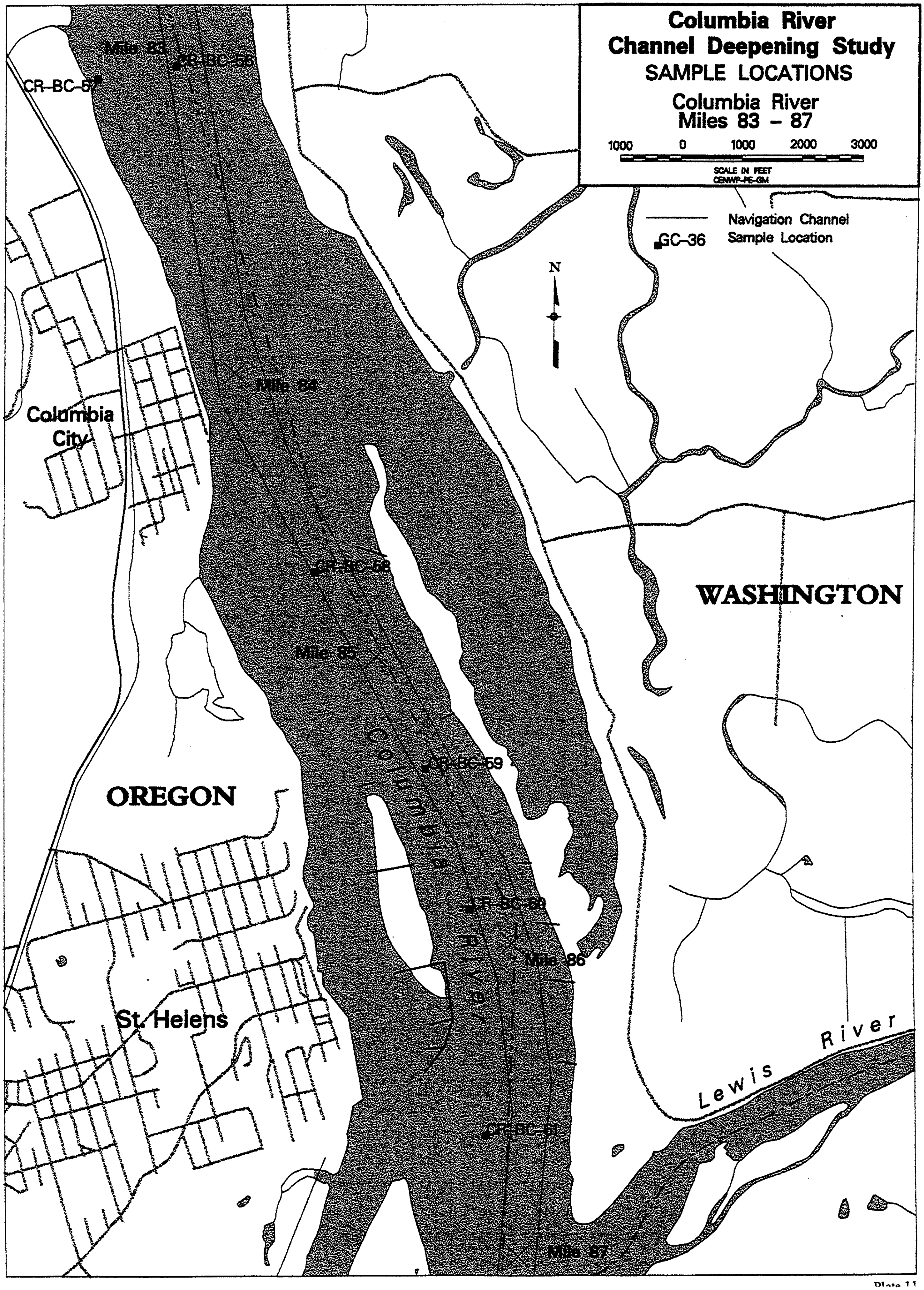
Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 99 – 103
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
WASHINGTON
OREGON
Sauvie
Island
Vancouver Lake
Columbia River
Oregon Slough
Mile 99
Mile 100
Mile 101
Mile 102
Mile 103
Mile 0
Mile 1
Mile 2
CR-BC-75
CR-BC-74
CR-BC-73
CR-BC-76
CR-BC-77
CR-BC-78
CR-BC-79
GC-02
BC-01
WR-BC-03
WR-GC-06
WR-GC-05
WR-GC-04
WR-BC-07
WR-BC-08
GC-09
N
New Navigation Channel
Original Navigation Channel
GC-36 Sample Location

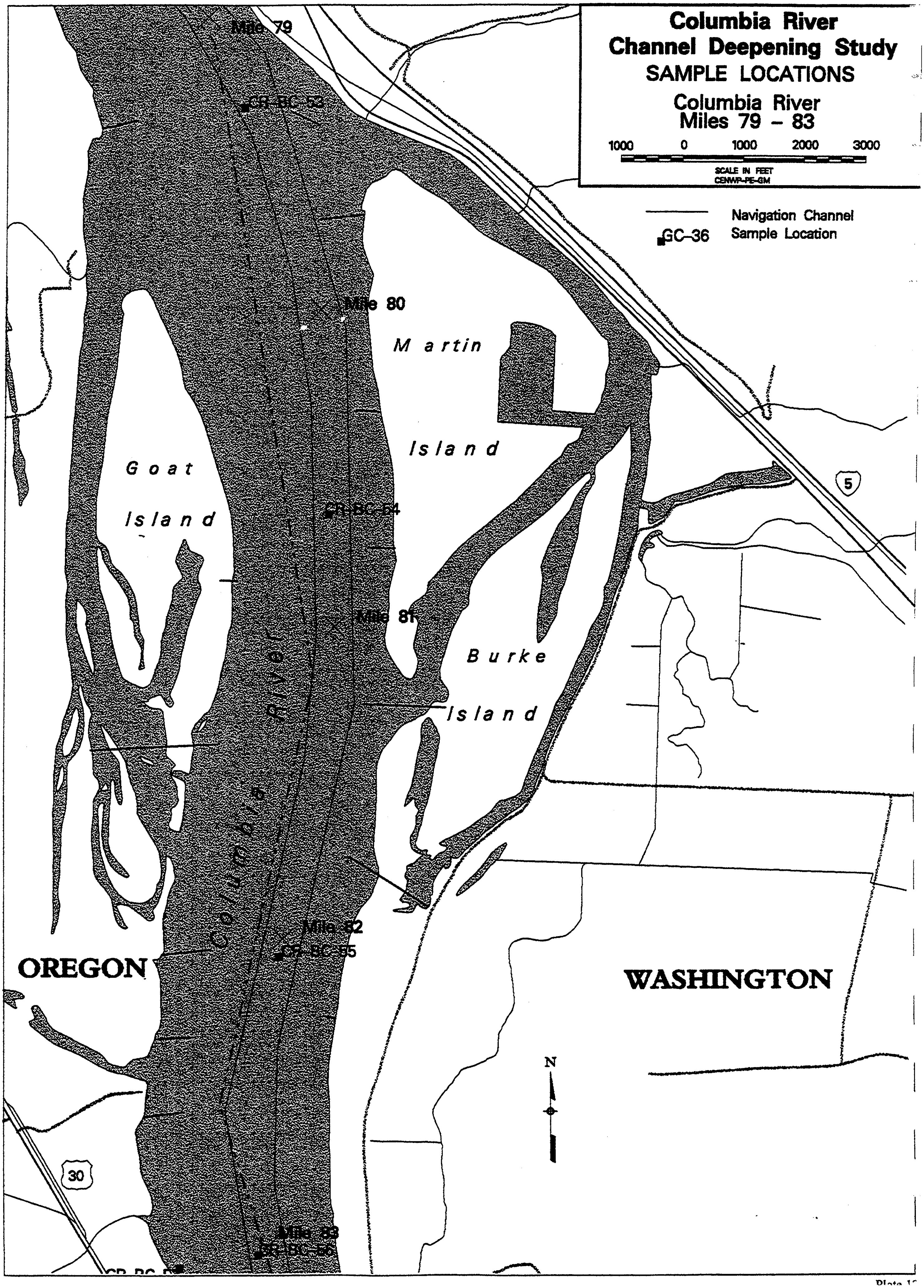

Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 95 - 99
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
CR-BC-69
Mile 95
Mile 96
CR-BC-70
OREGON
Sauvie Island
Columbia River
Mile 97
CR-BC-71
N
Navigation Channel
GC-36 Sample Location
Mile 98
CR-BC-72
WASHINGTON
Vancouver Lake

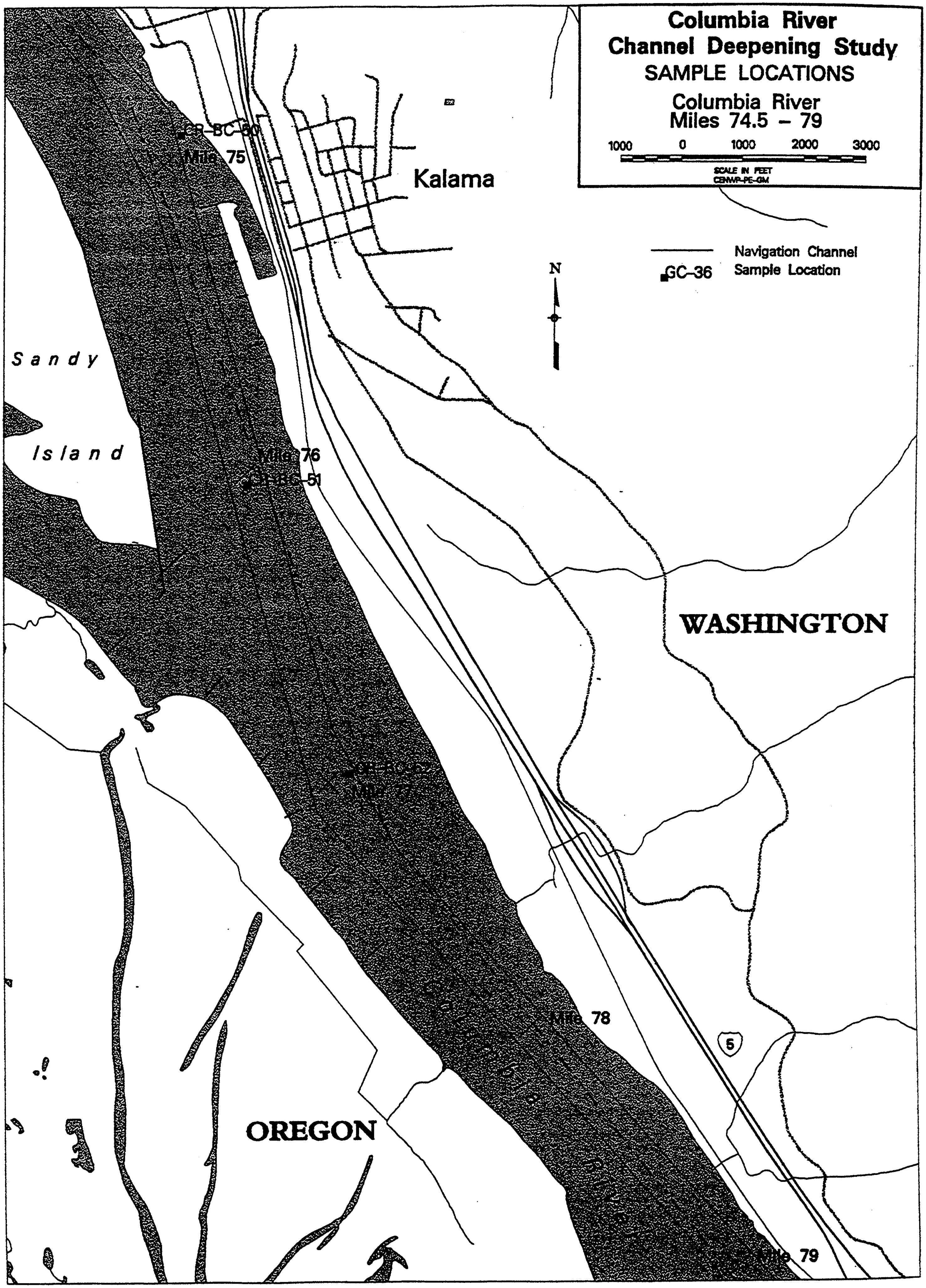

Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 91 – 95
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
WASHINGTON
Navigation Channel
Sample Location
GC-36
CR-BC-65
Mile 91
Mile 92
CR-BC-66
CR-BC-67
Mile 93
Columbia River
Lake River
Campbell Lake
N
Sauvie Island
CR-BC-68
Mile 94
OREGON
Sturgeon Lake
Mile 95
CR-BC-69



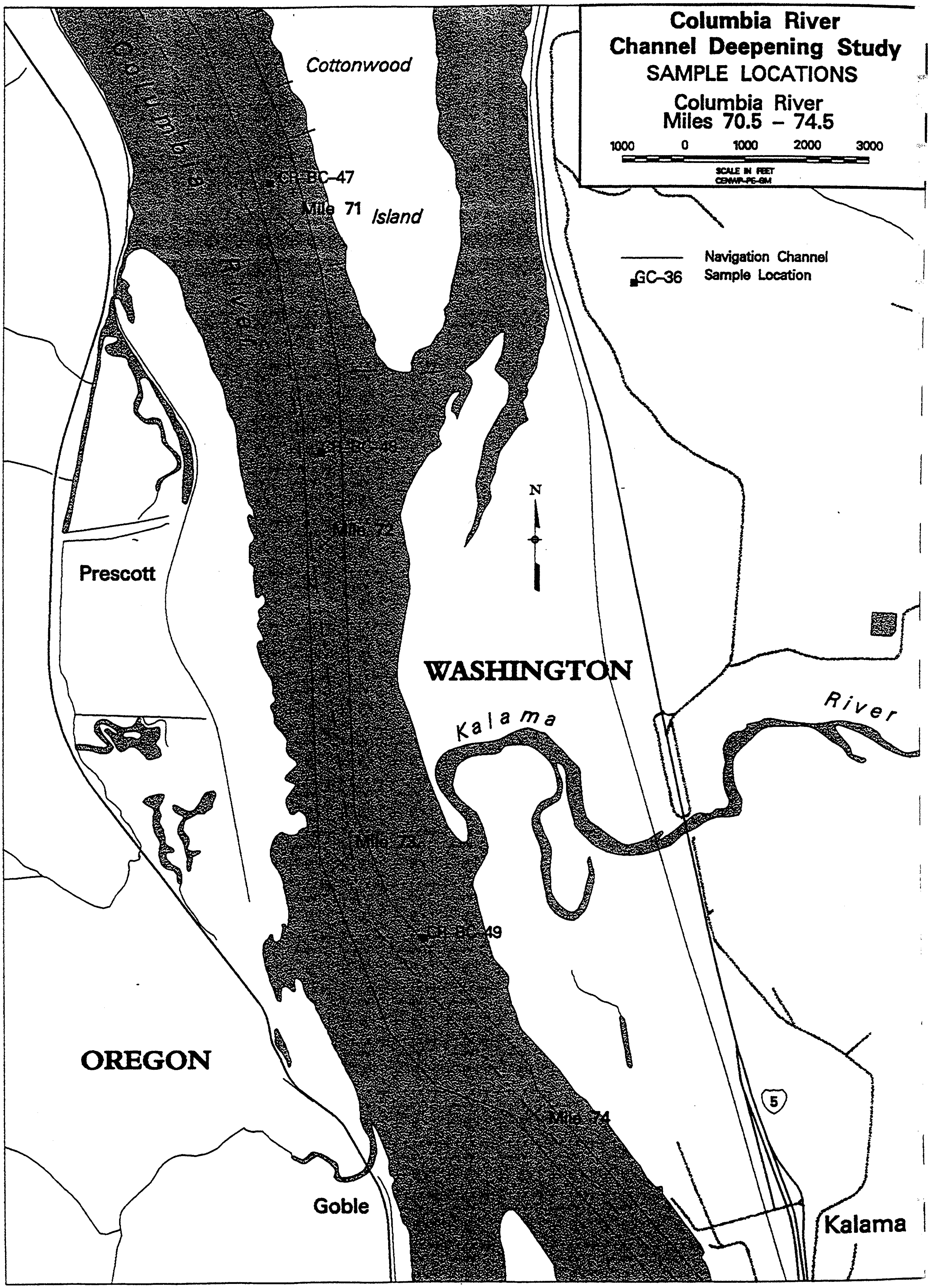
Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 87 - 91
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
GC-36 Sample Location
Mile 87
CR-BC-62
Mile 88
CR-BC-63
Mile 89
CR-BC-64
Mile 90
CR-BC-65
Mile 91
Multnomah Channel
Columbia River
Lake River
N
Sauvie Island
WASHINGTON
OREGON


Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 83 - 87
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
GC-36 Sample Location
N
Mile 83
CR-BC-56
CR-BC-57
Mile 84
Columbia City
CR-BC-58
WASHINGTON
Mile 85
Columbia
CR-BC-59
OREGON
CR-BC-60
River
Mile 86
St. Helens
Lewis River
CR-BC-61
Mile 87

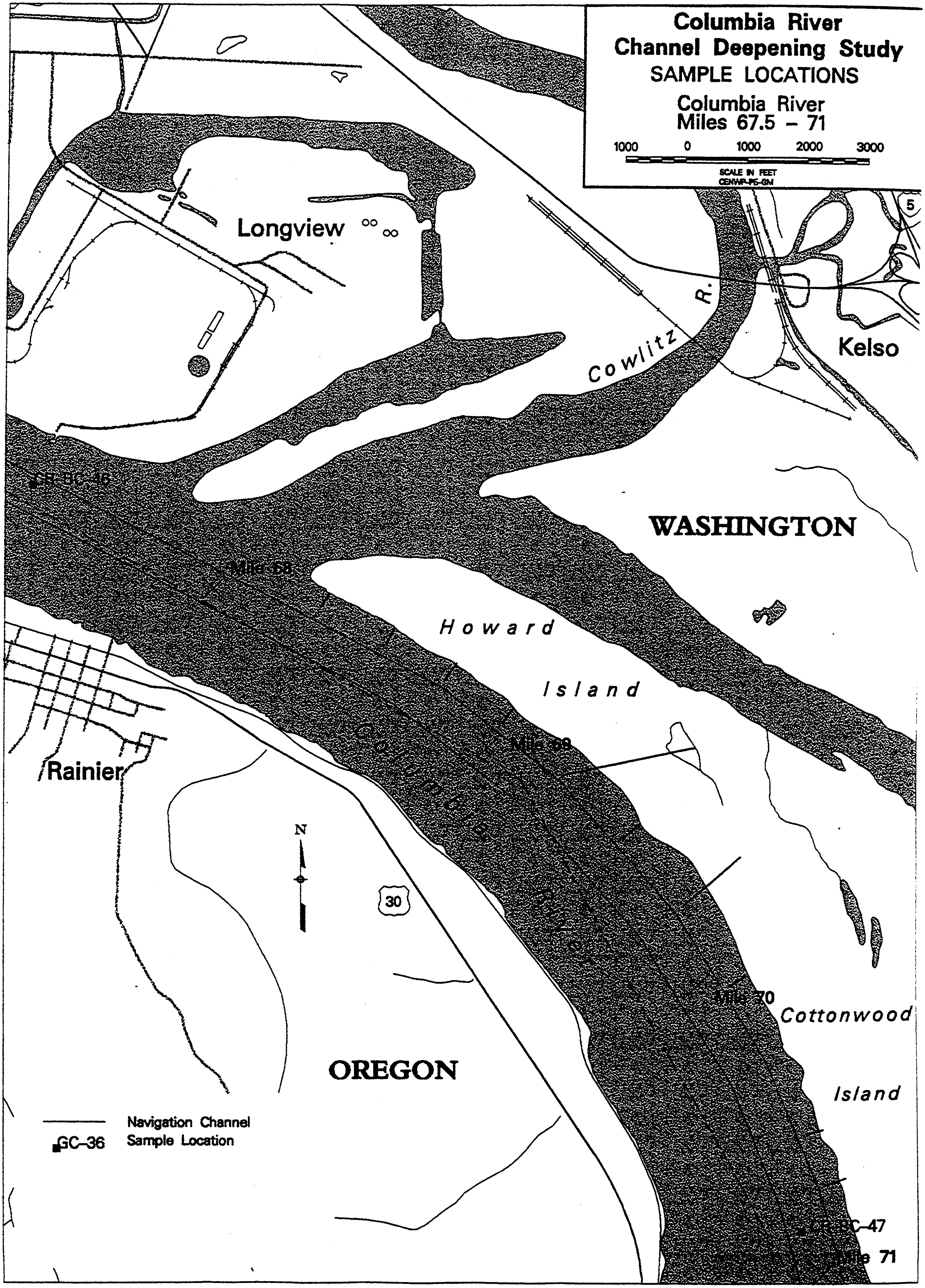

Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 79 – 83
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
GC-36
Sample Location
Mile 79
CR-BC-53
Mile 80
Martin
Island
Goat
Island
CR-BC-54
Mile 81
Burke
Island
Columbia River
Mile 82
CR-BC-55
OREGON
WASHINGTON
5
N
30
Mile 83
CR-BC-56



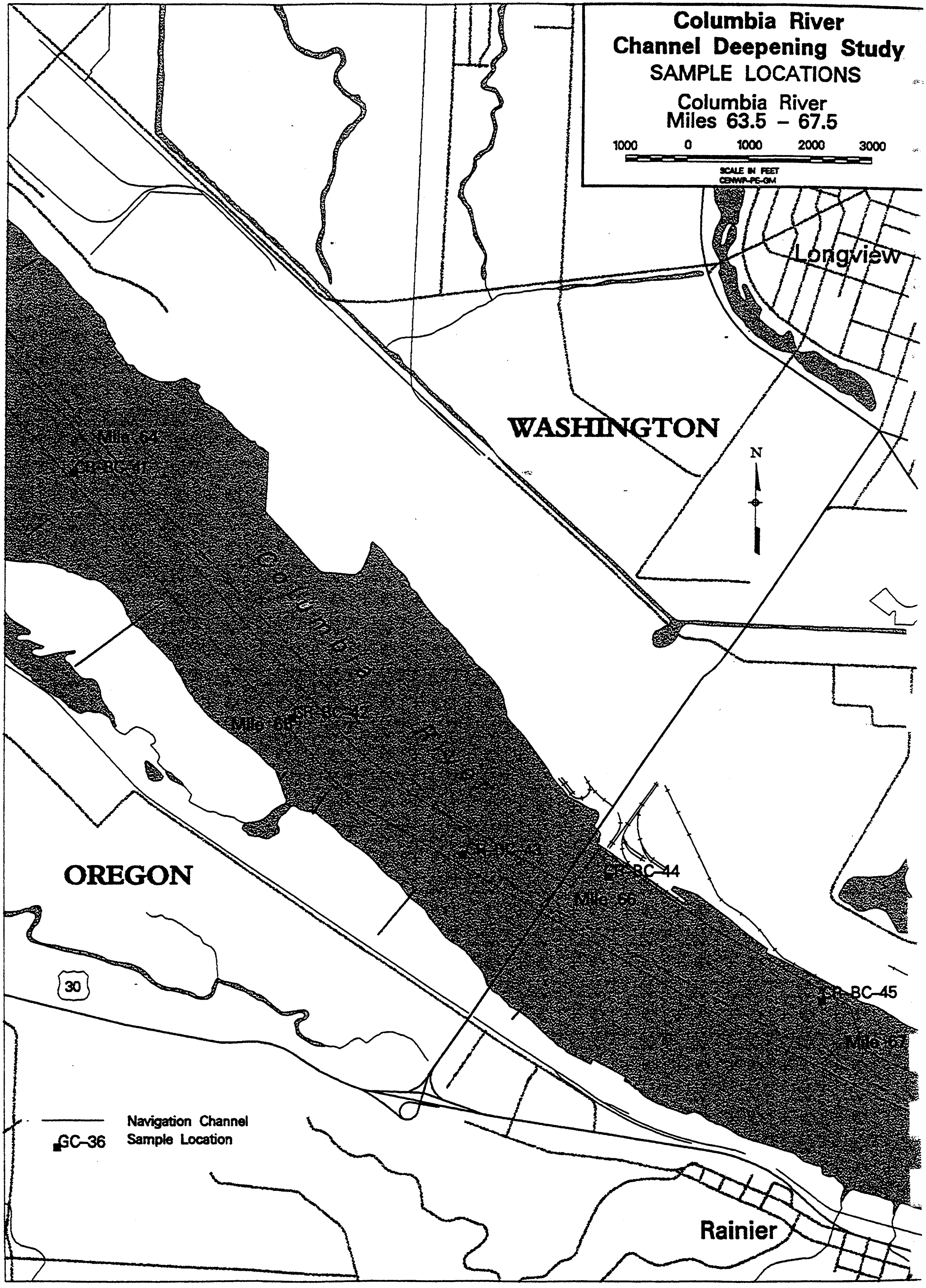
Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 74.5 – 79
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
GC-36 Sample Location
N
Kalama
CR-BC-50
Mile 75
Sandy
Island
Mile 76
CR-BC-51
WASHINGTON
Mile 78
5
OREGON
Mile 79



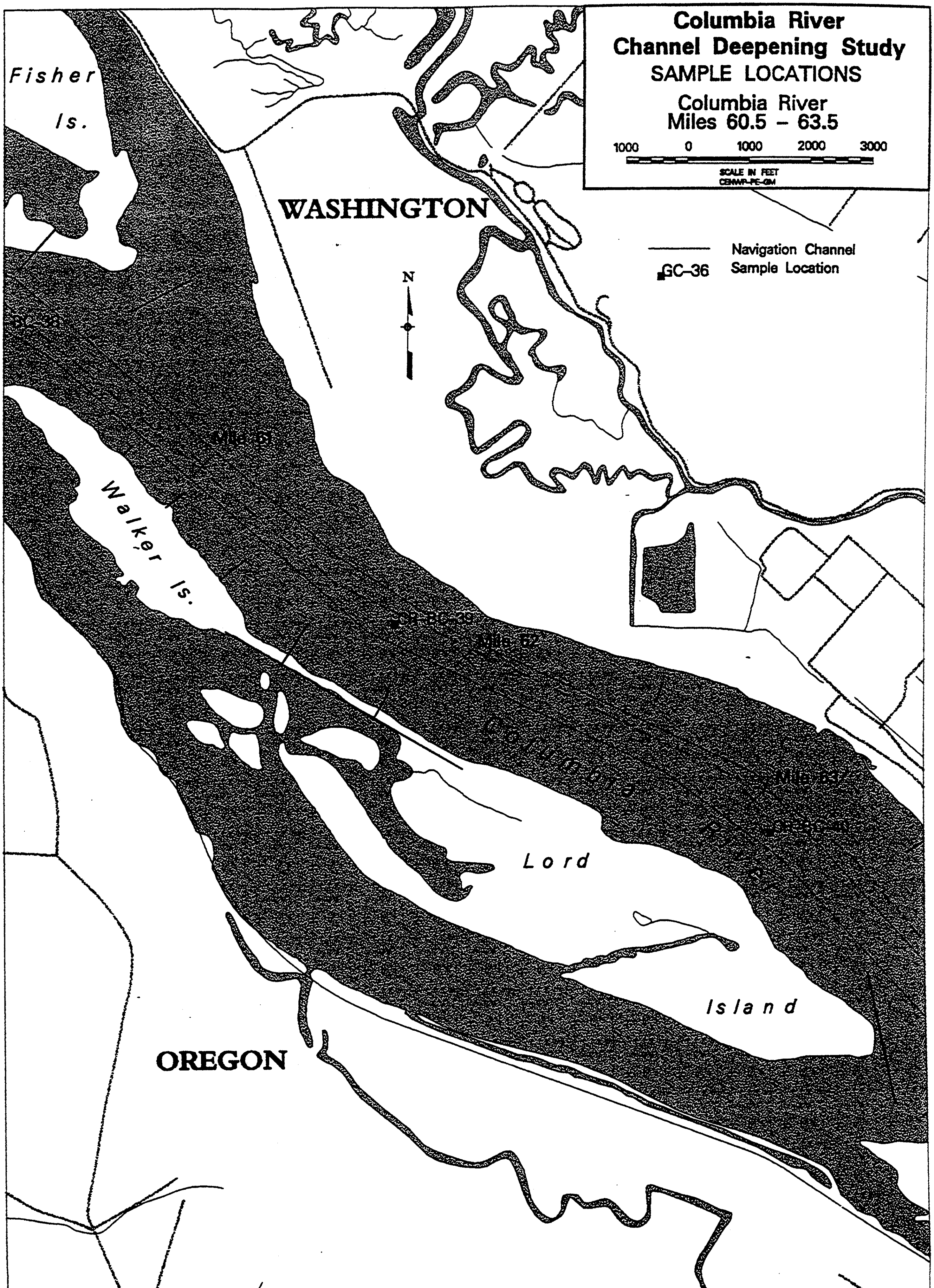
Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 70.5 – 74.5
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
GC-36 Sample Location
Cottonwood
Island
Mile 71
Mile 72
Mile 73
Mile 74
N
Prescott
WASHINGTON
Kalama River
OREGON
5
Goble
Kalama

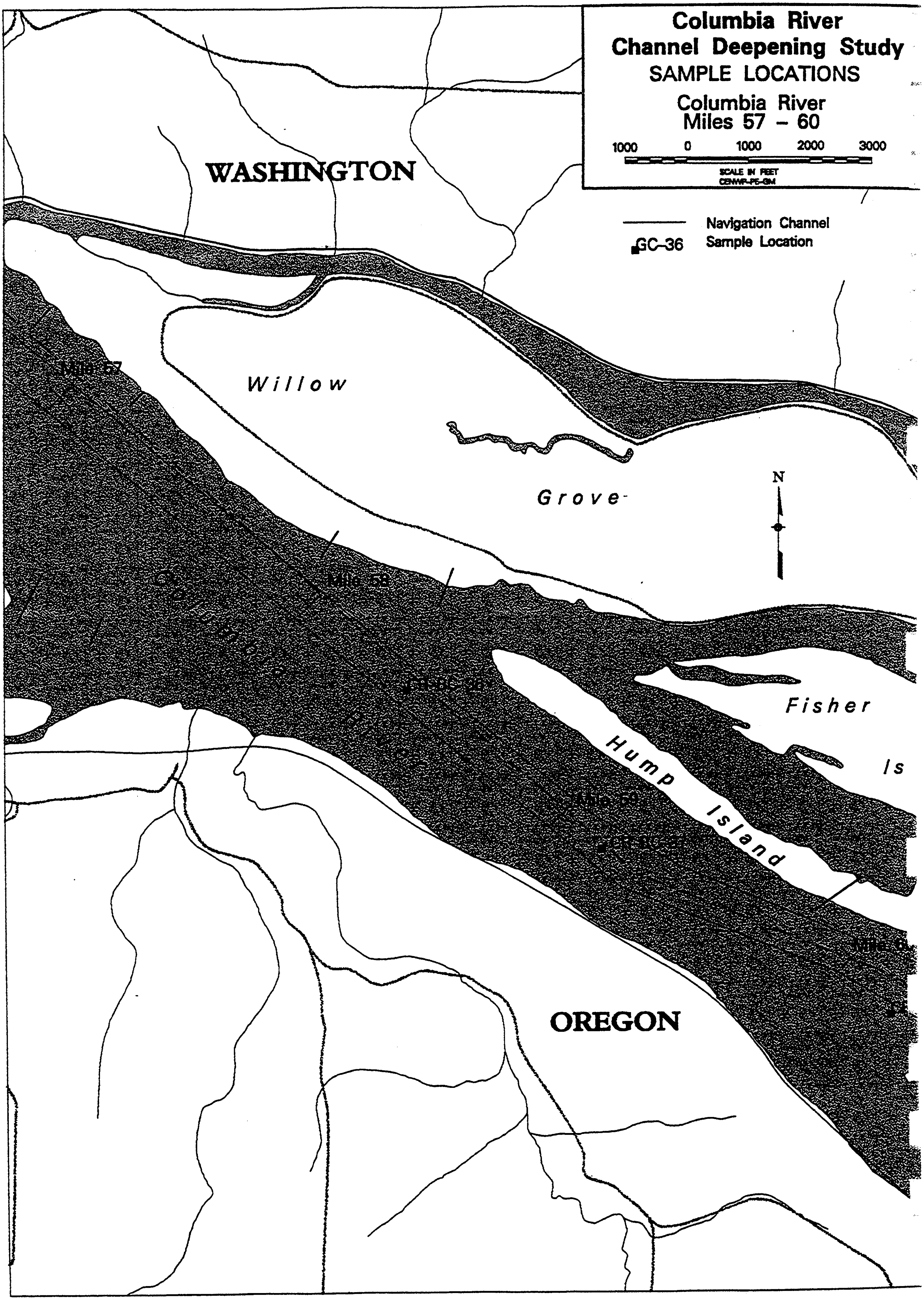


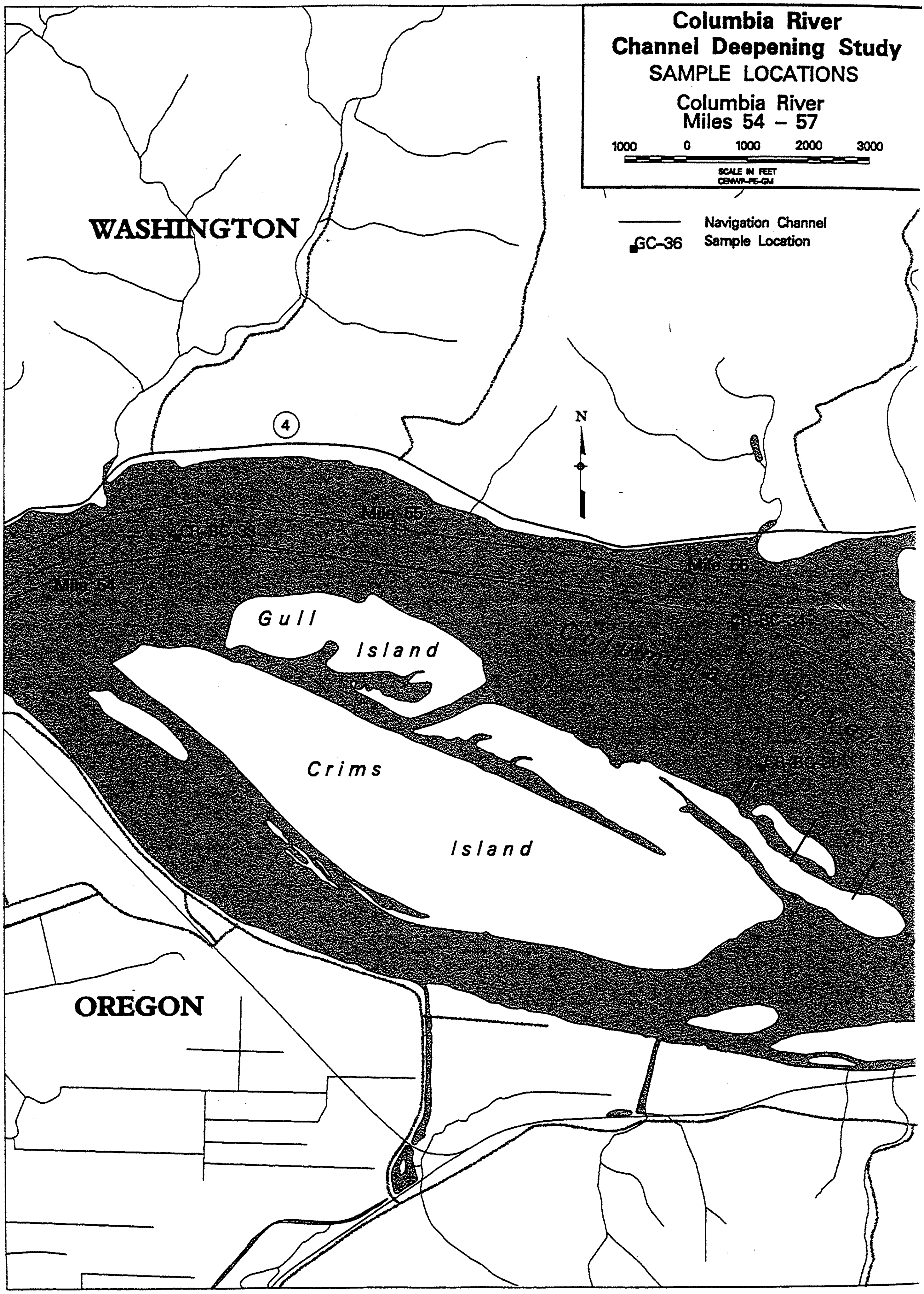
Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 67.5 – 71
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Longview
Kelso
Cowlitz R.
5
WASHINGTON
Howard Island
Mile 68
Mile 69
Mile 70
Mile 71
Columbia River
Cottonwood Island
Rainier
N
30
OREGON
Navigation Channel
GC-36 Sample Location



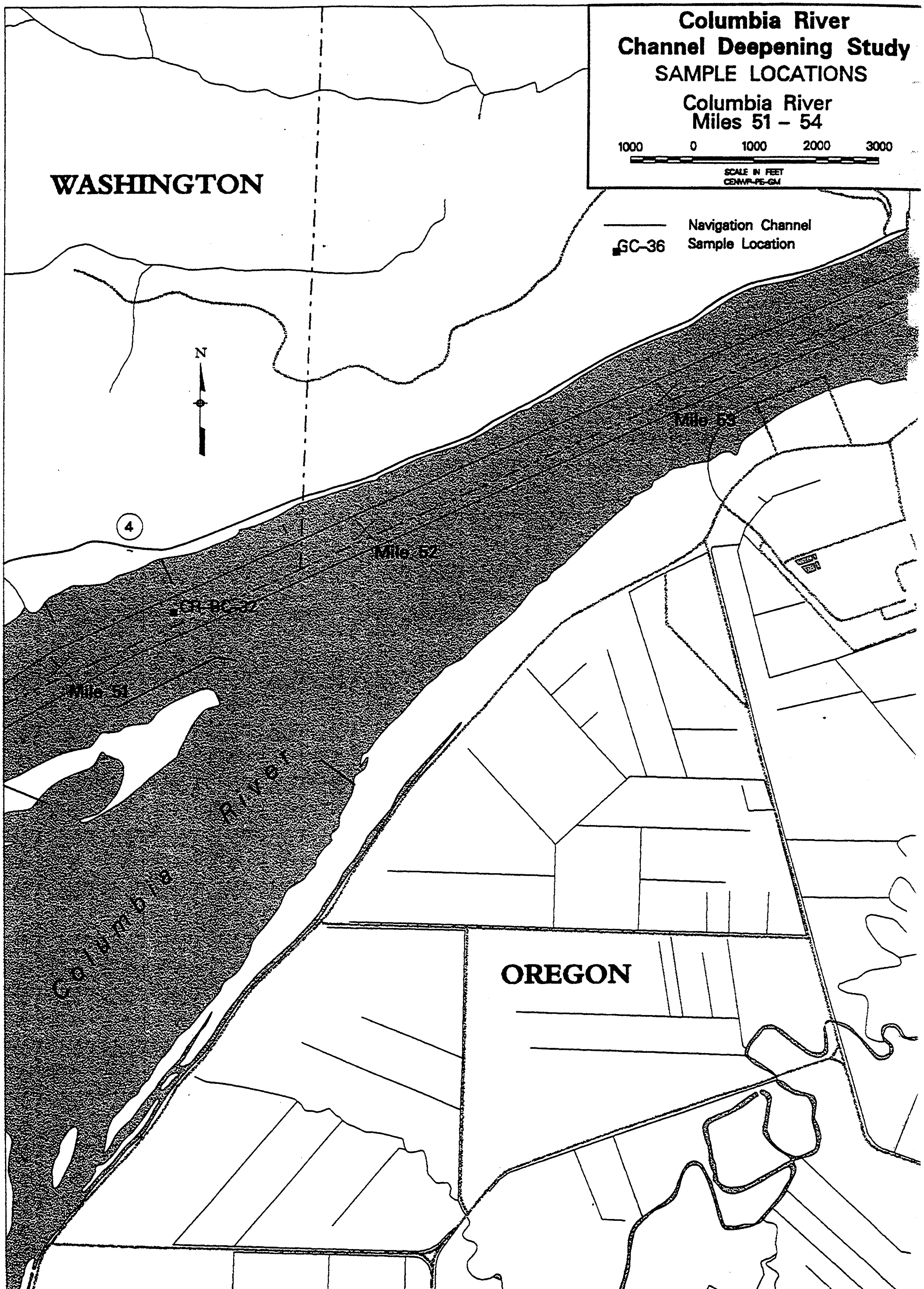
Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 63.5 – 67.5
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Longview
WASHINGTON
N
Mile 64
Mile 65
CR-BC-42
CR-BC-44
Mile 66
CR-BC-45
Mile 67
OREGON
30
Navigation Channel
GC-36 Sample Location
Rainier

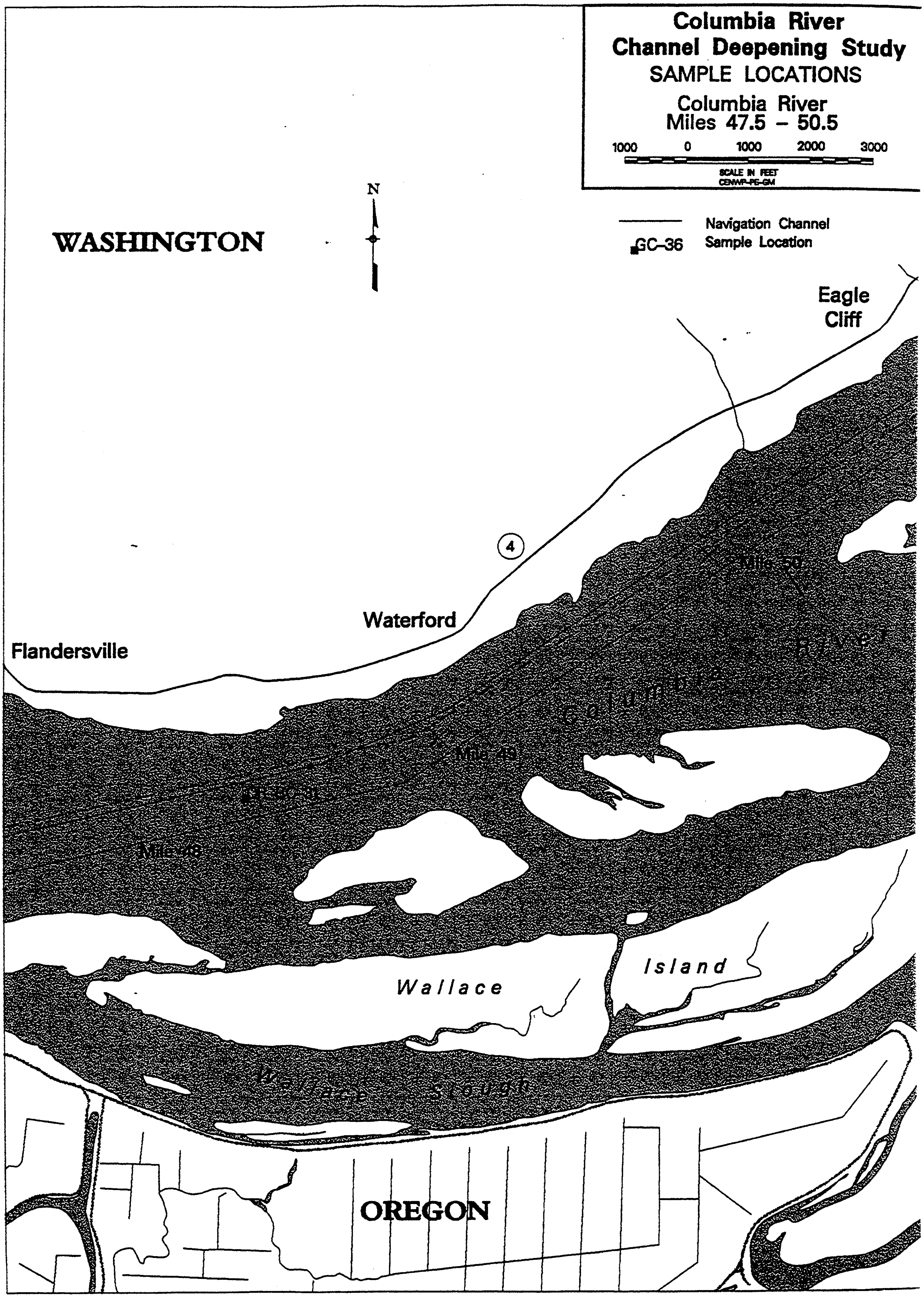

Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 60.5 – 63.5
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
GC-36 Sample Location
N
WASHINGTON
OREGON
Fisher Is.
Walker Is.
Lord Island
Mile 61
Mile 62
Mile 63

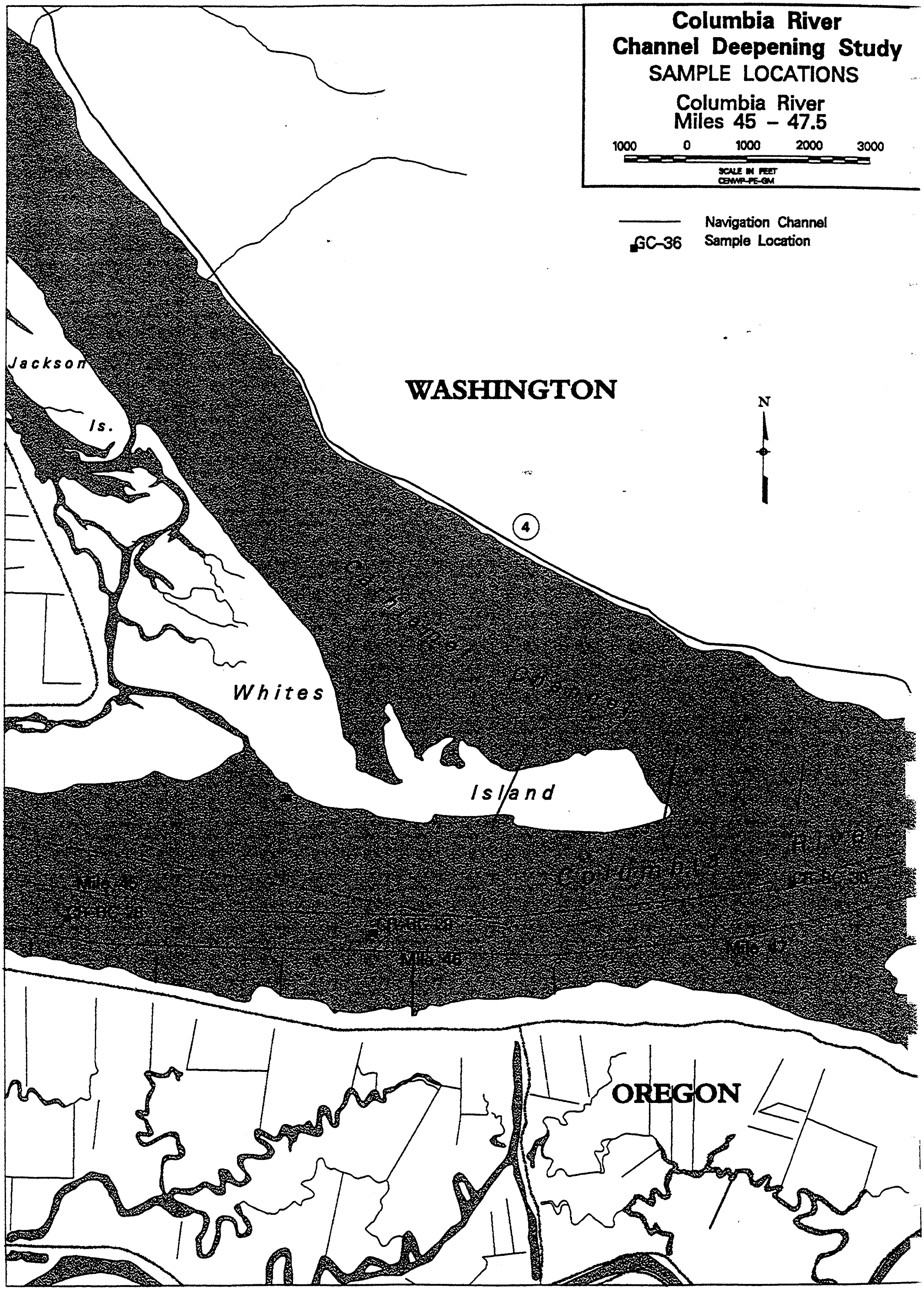

Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 57 - 60
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
GC-36 Sample Location
WASHINGTON
Willow
Grove
N
Mile 57
Mile 58
Mile 59
Hump Island
Fisher
Is
OREGON

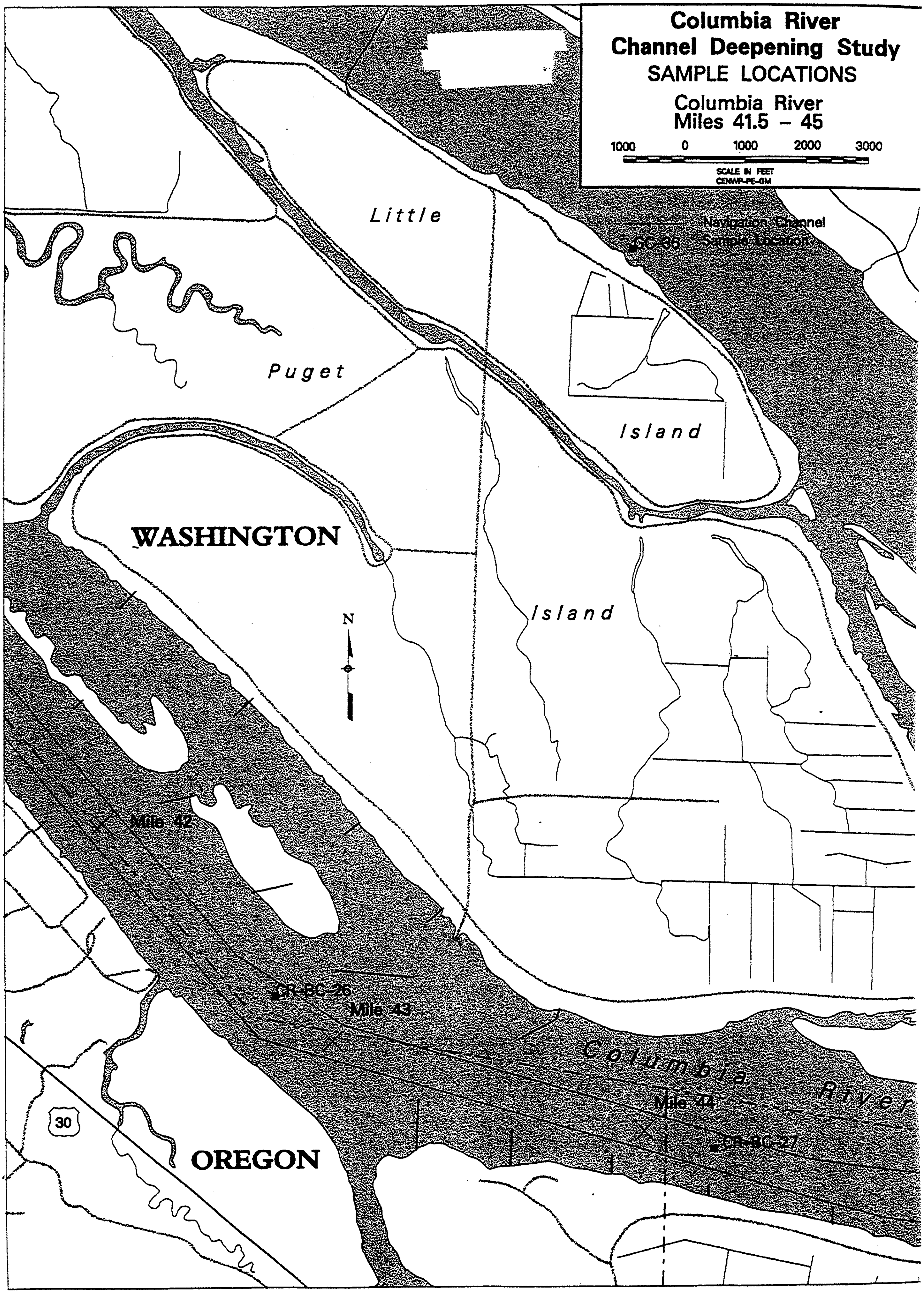


Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 54 - 57
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
GC-36 Sample Location
WASHINGTON
OREGON
4
N
Mile 54
Mile 55
Mile 56
Gull Island
Crims Island

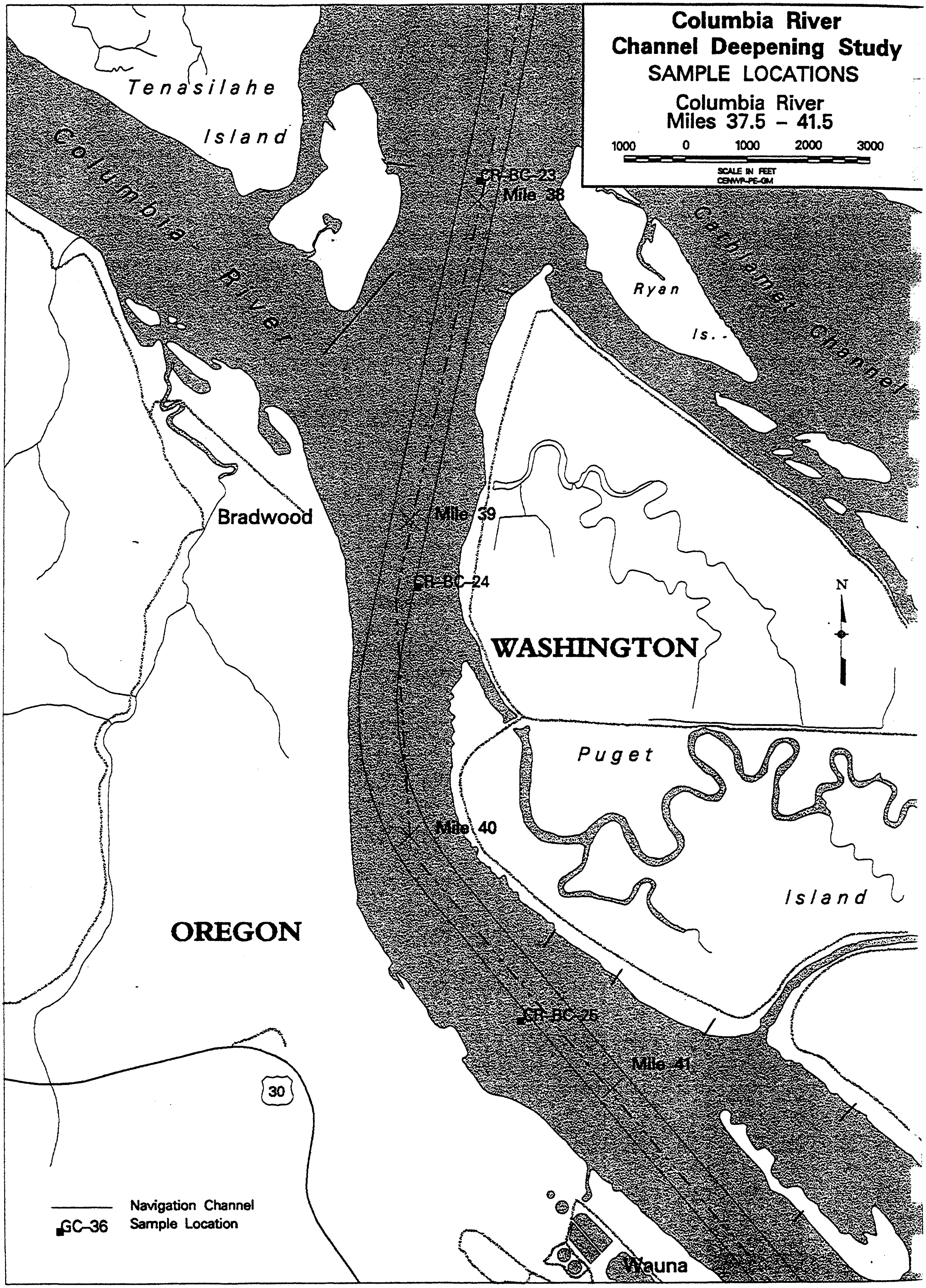

Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 51 – 54
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
GC-36 Sample Location
WASHINGTON
N
4
Mile 51
Mile 52
Mile 53
CR-BC-32
Columbia River
OREGON


Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 47.5 – 50.5
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
N
WASHINGTON
Navigation Channel
GC-36 Sample Location
Eagle Cliff
4
Waterford
Flandersville
Mile 50
Mile 49
Mile 48
Wallace Island
Wallace Slough
OREGON

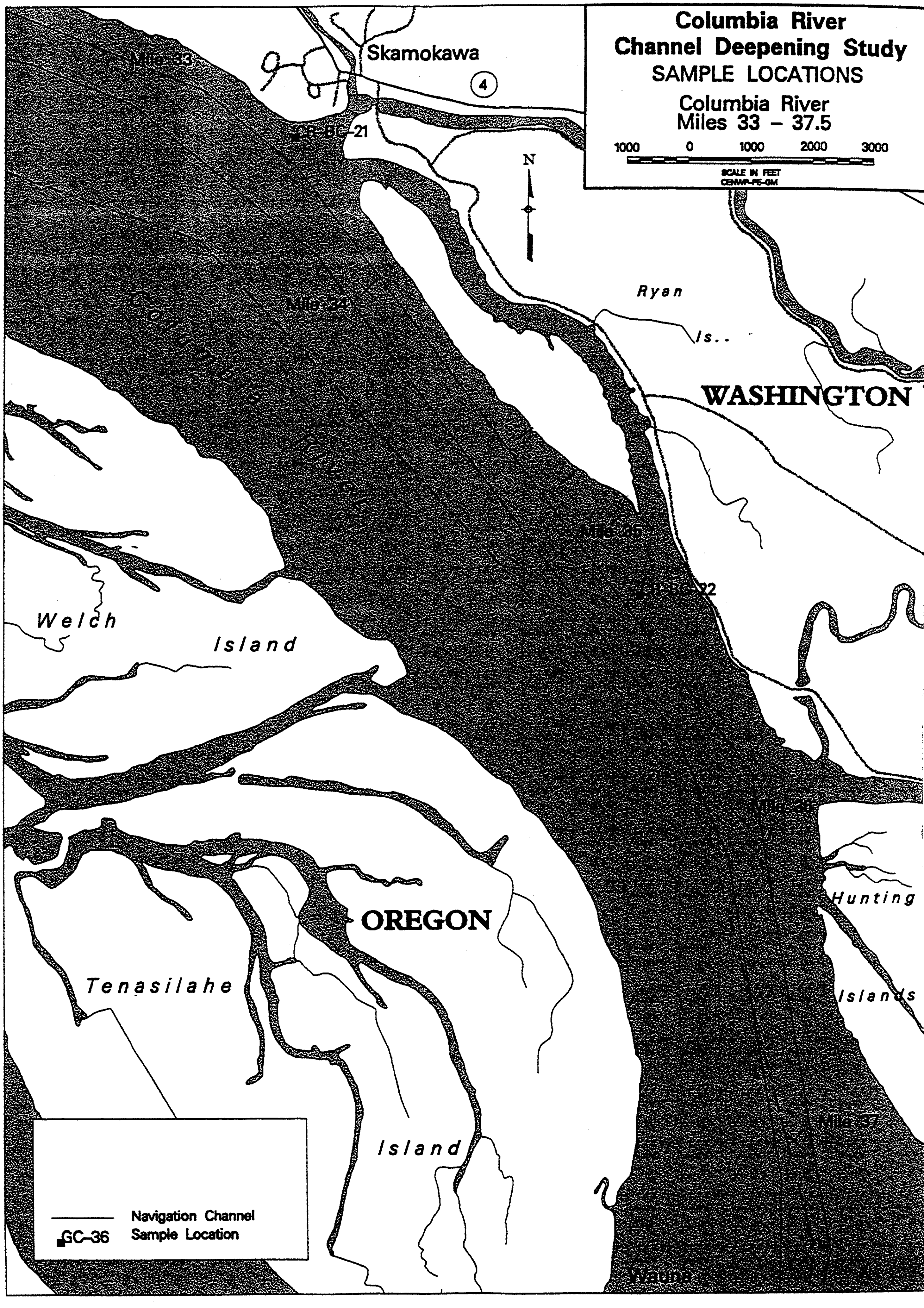

Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 45 – 47.5
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
GC-36 Sample Location
WASHINGTON
N
4
Jackson
Is.
Whites
Island
OREGON



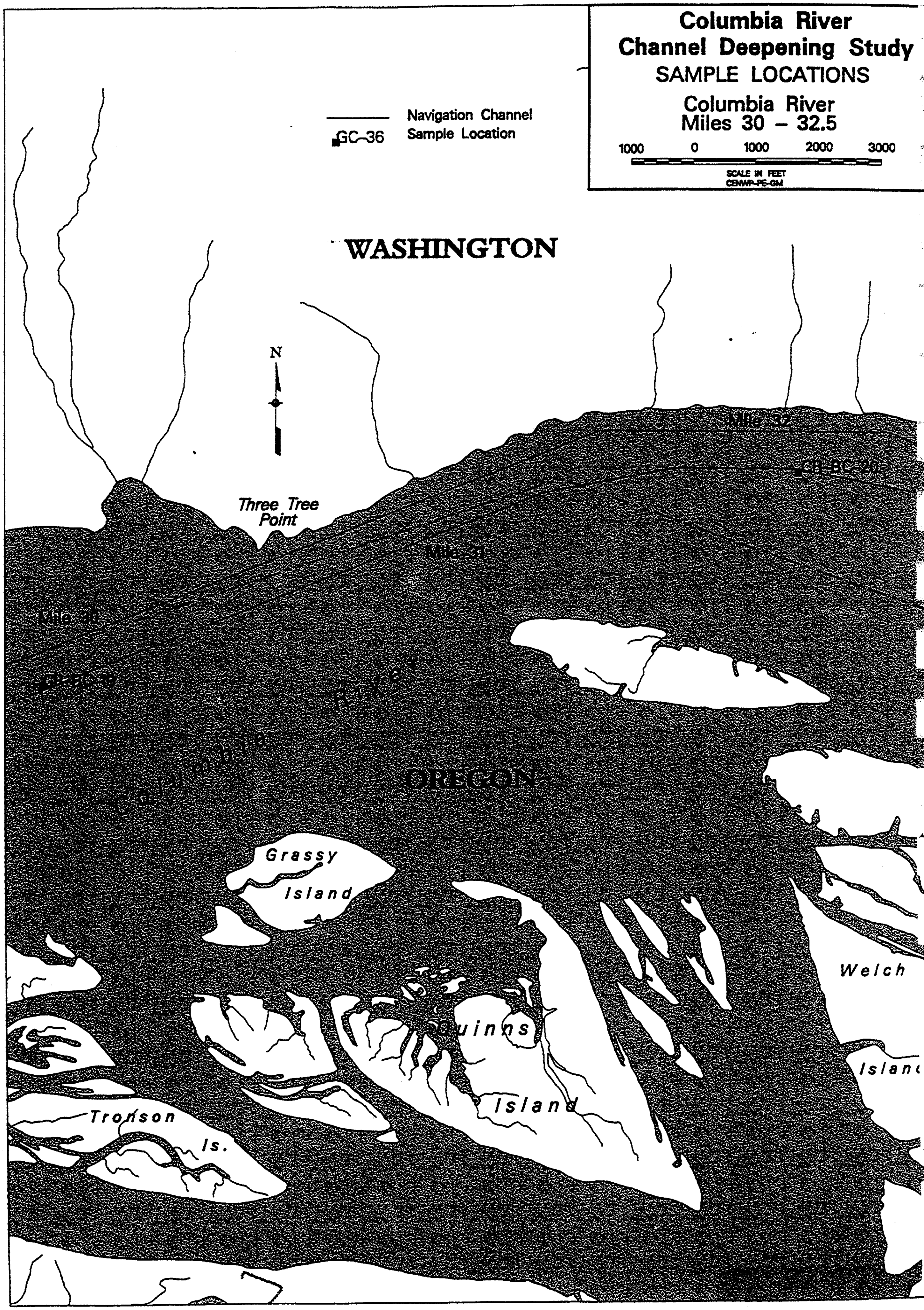
Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 41.5 – 45
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
Sample Location
GC-36
Little
Puget
Island
WASHINGTON
Island
N
Mile 42
CR-BC-26
Mile 43
Columbia
River
Mile 44
CR-BC-27
30
OREGON



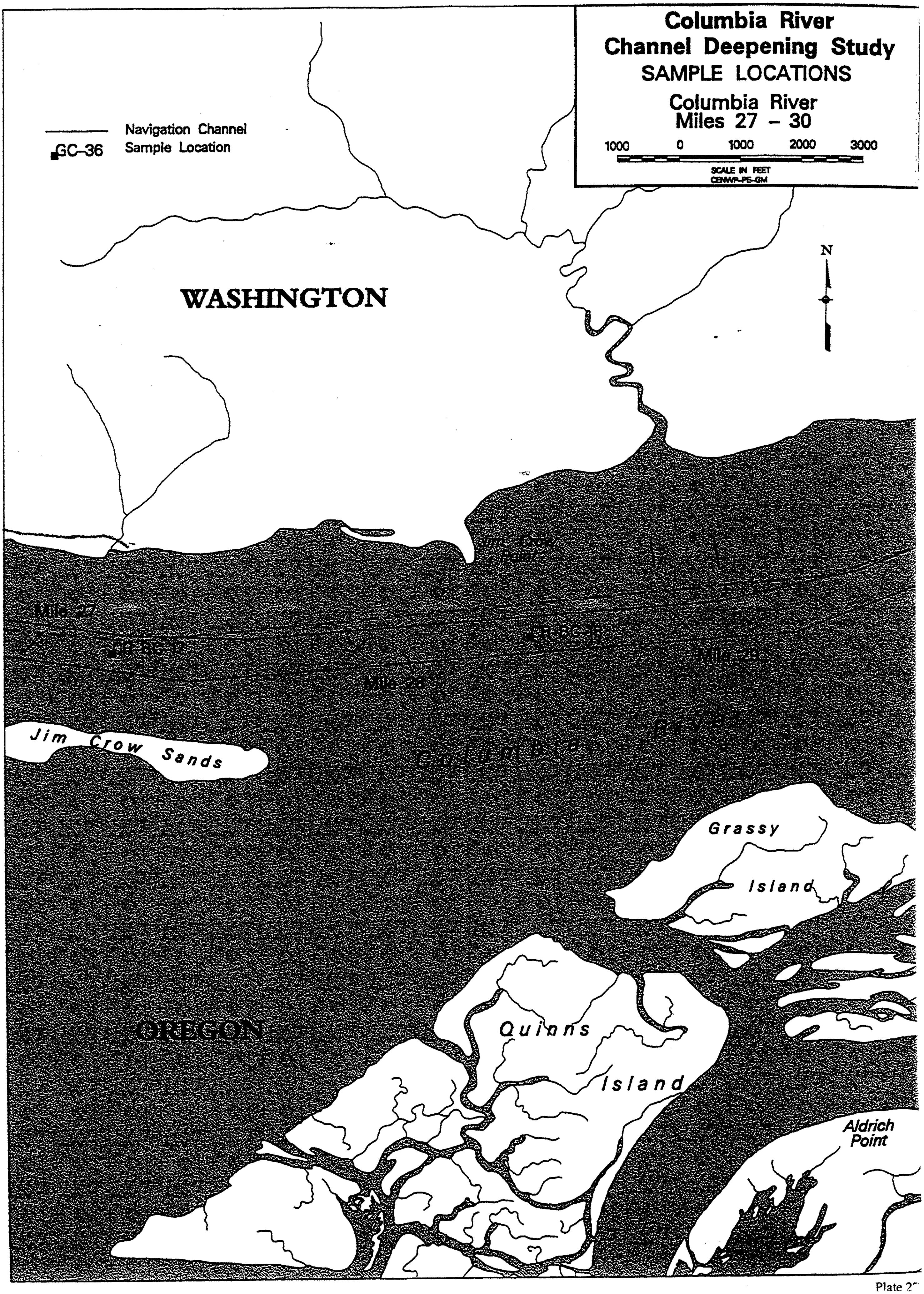
Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 37.5 - 41.5
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Tenasilahe
Island
Columbia River
CR-BC-23
Mile 38
Cathlamet Channel
Ryan
Is.
Bradwood
Mile 39
CR-BC-24
N
WASHINGTON
Puget
Island
Mile 40
OREGON
CR-BC-25
Mile 41
30
Navigation Channel
GC-36 Sample Location
Wauna

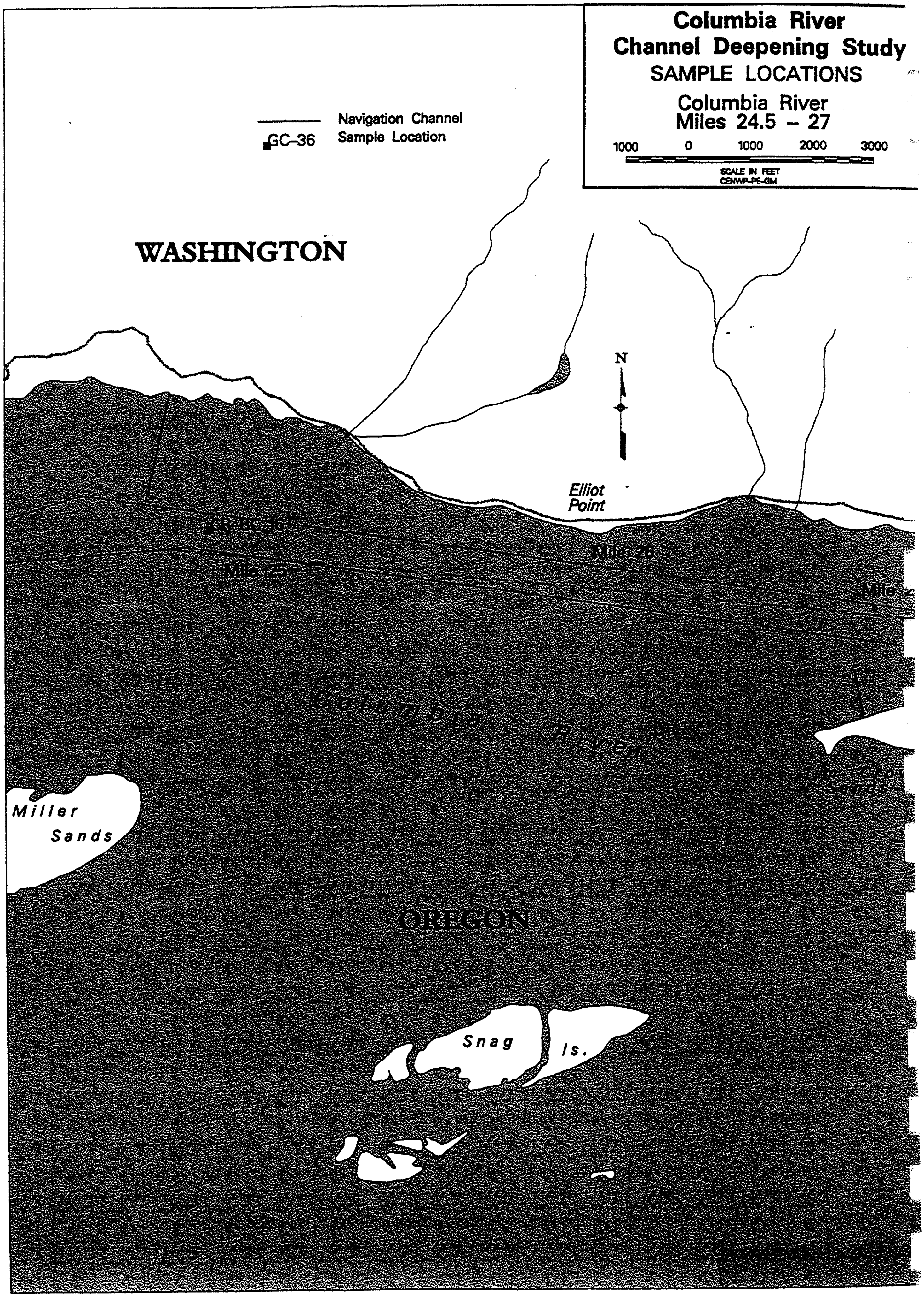


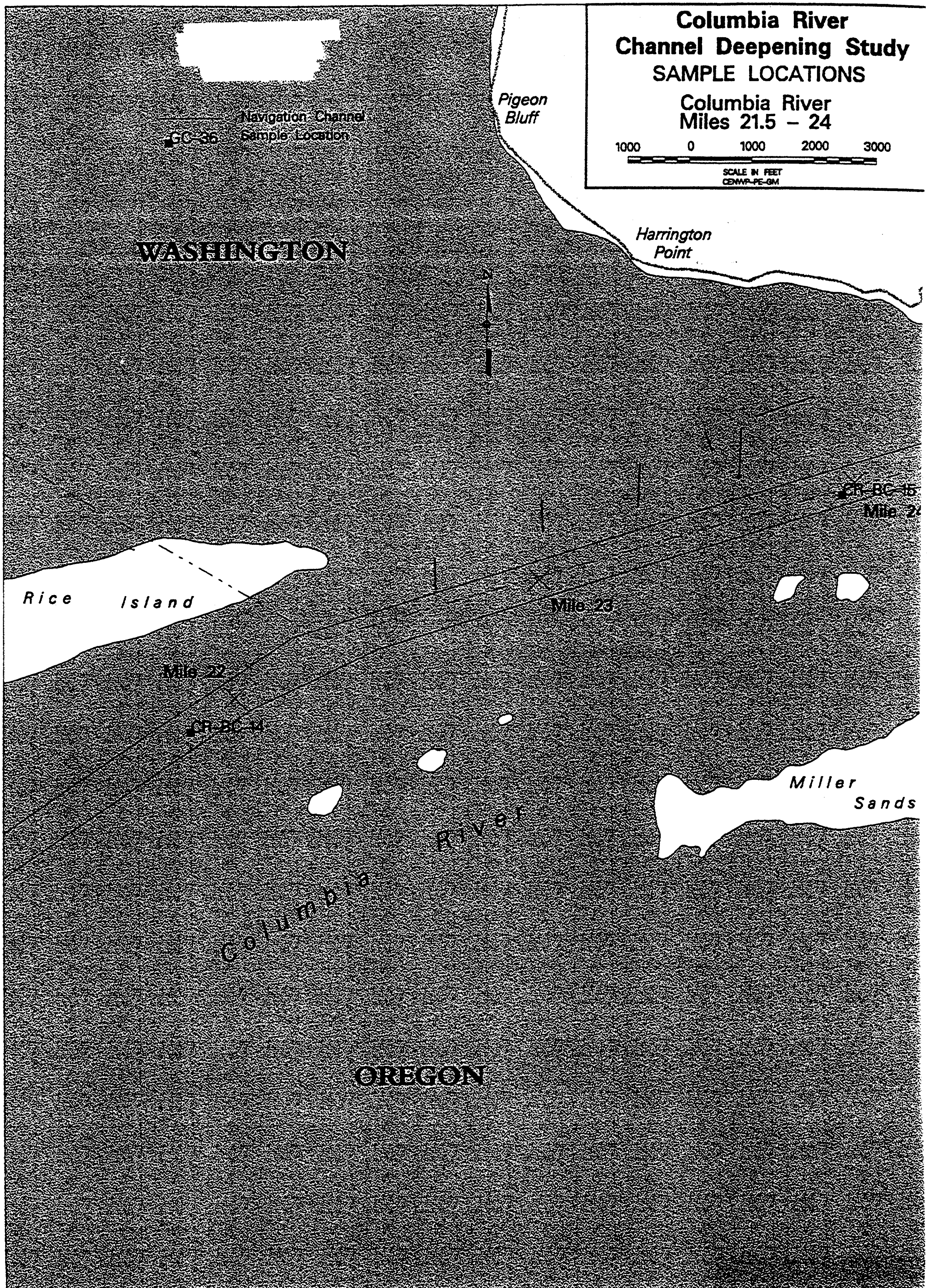
Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 33 – 37.5
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Skamokawa
4
N
Ryan
Is..
WASHINGTON
Mile 35
Welch
Island
Mile 36
Hunting
Islands
OREGON
Tenasilahe
Island
Navigation Channel
GC-36 Sample Location



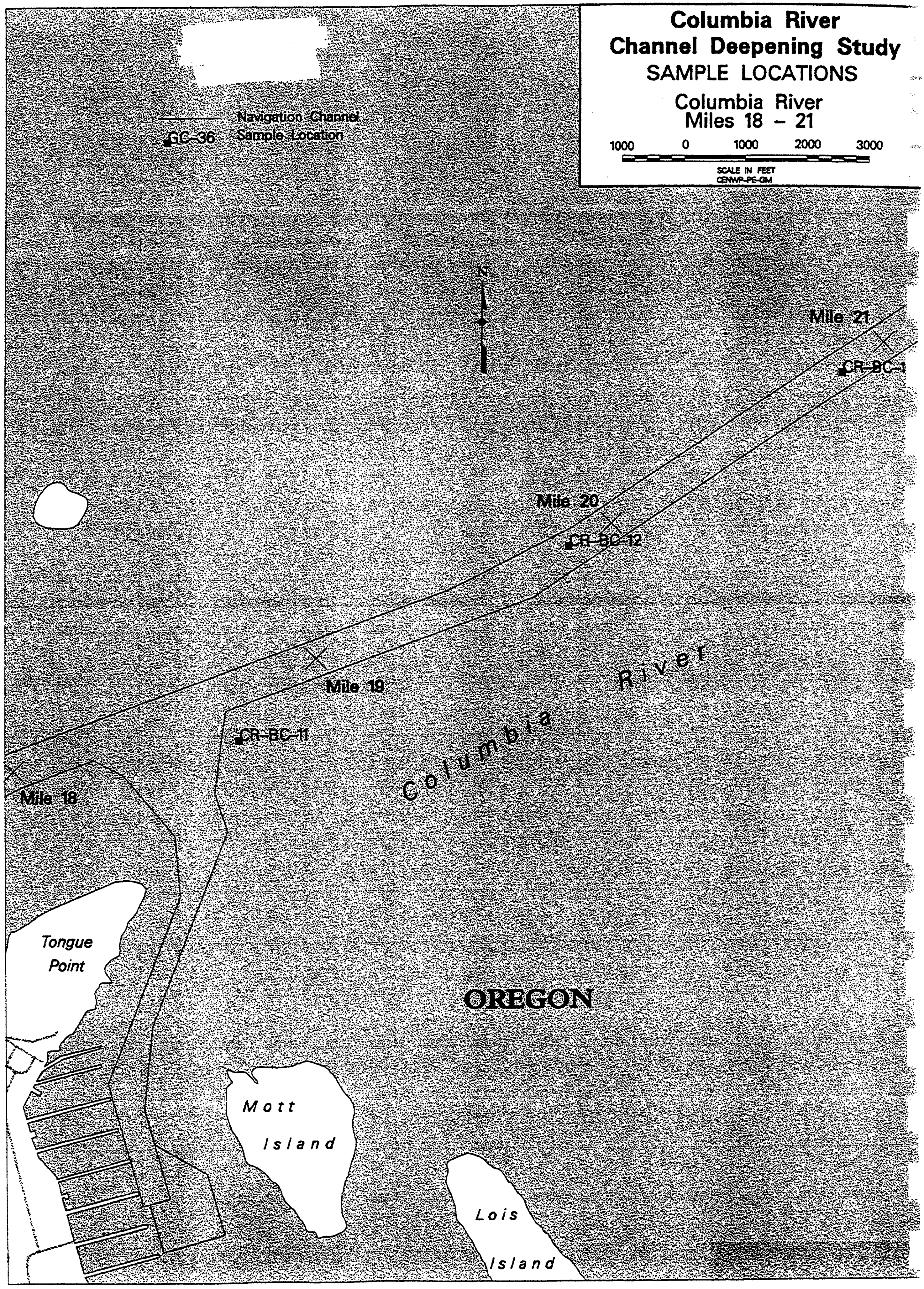
Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 30 – 32.5
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
GC-36 Sample Location
WASHINGTON
N
Three Tree Point
Mile 32
Mile 31
Mile 30
OREGON
Grassy Island
Quinns Island
Tronson Is.
Welch Island

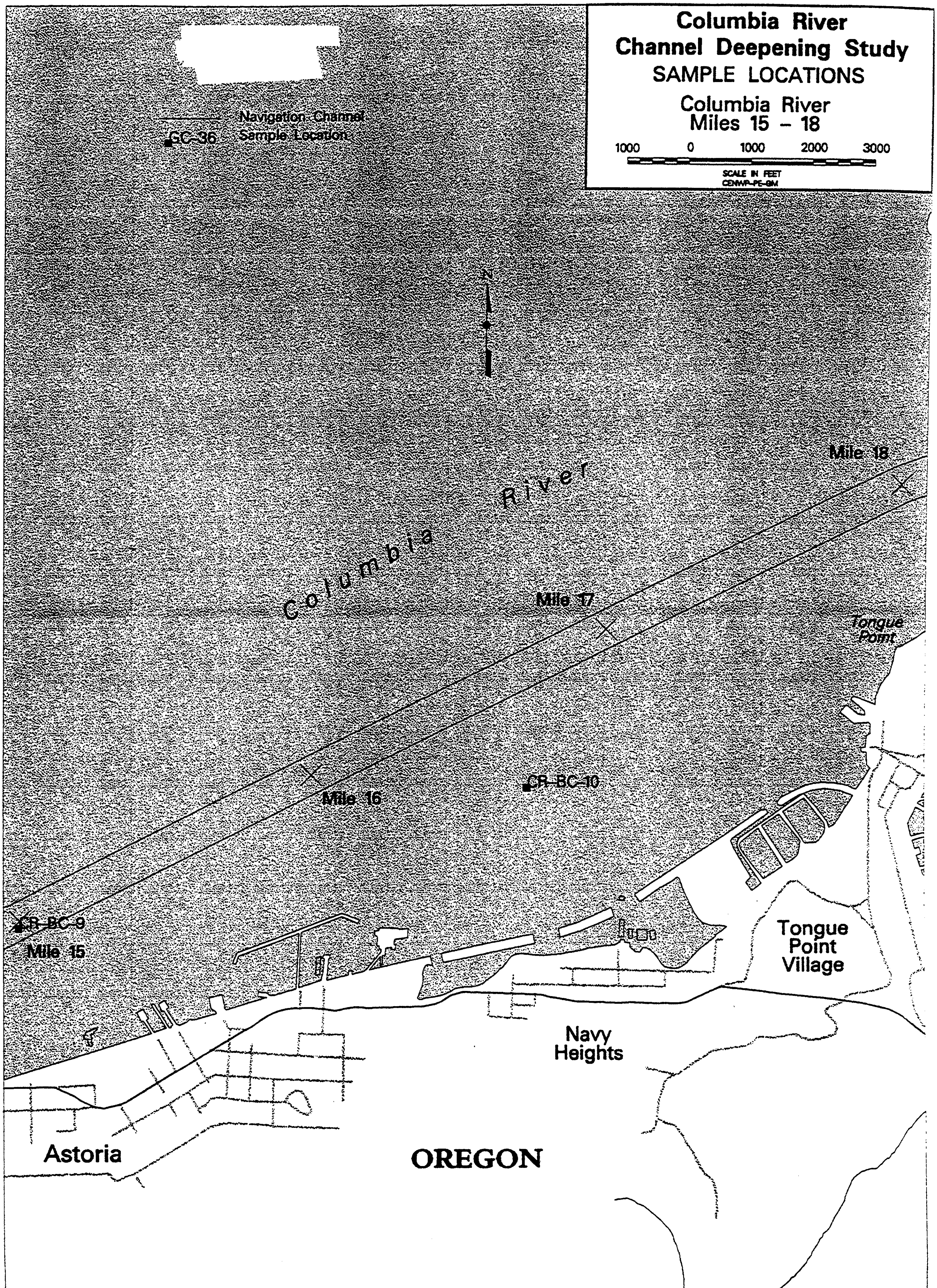

Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 27 - 30
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
GC-36 Sample Location
N
WASHINGTON
Mile 27
Mile 28
Mile 29
Jim Crow Sands
Grassy Island
OREGON
Quinns Island
Aldrich Point

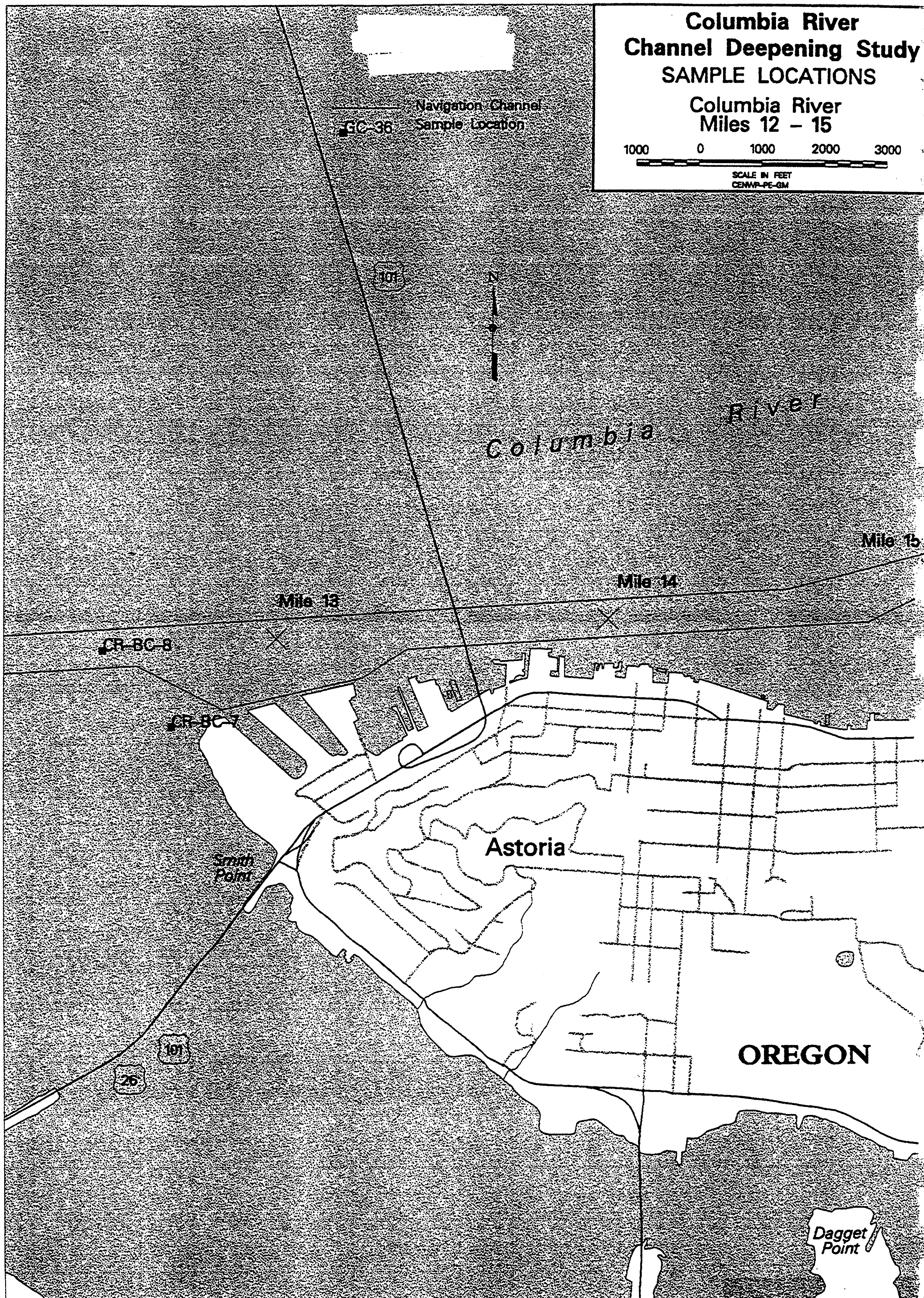

Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 24.5 – 27
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
GC-36 Sample Location
WASHINGTON
N
Elliot Point
Mile 25
Mile 26
Columbia River
Miller Sands
OREGON
Snag Is.



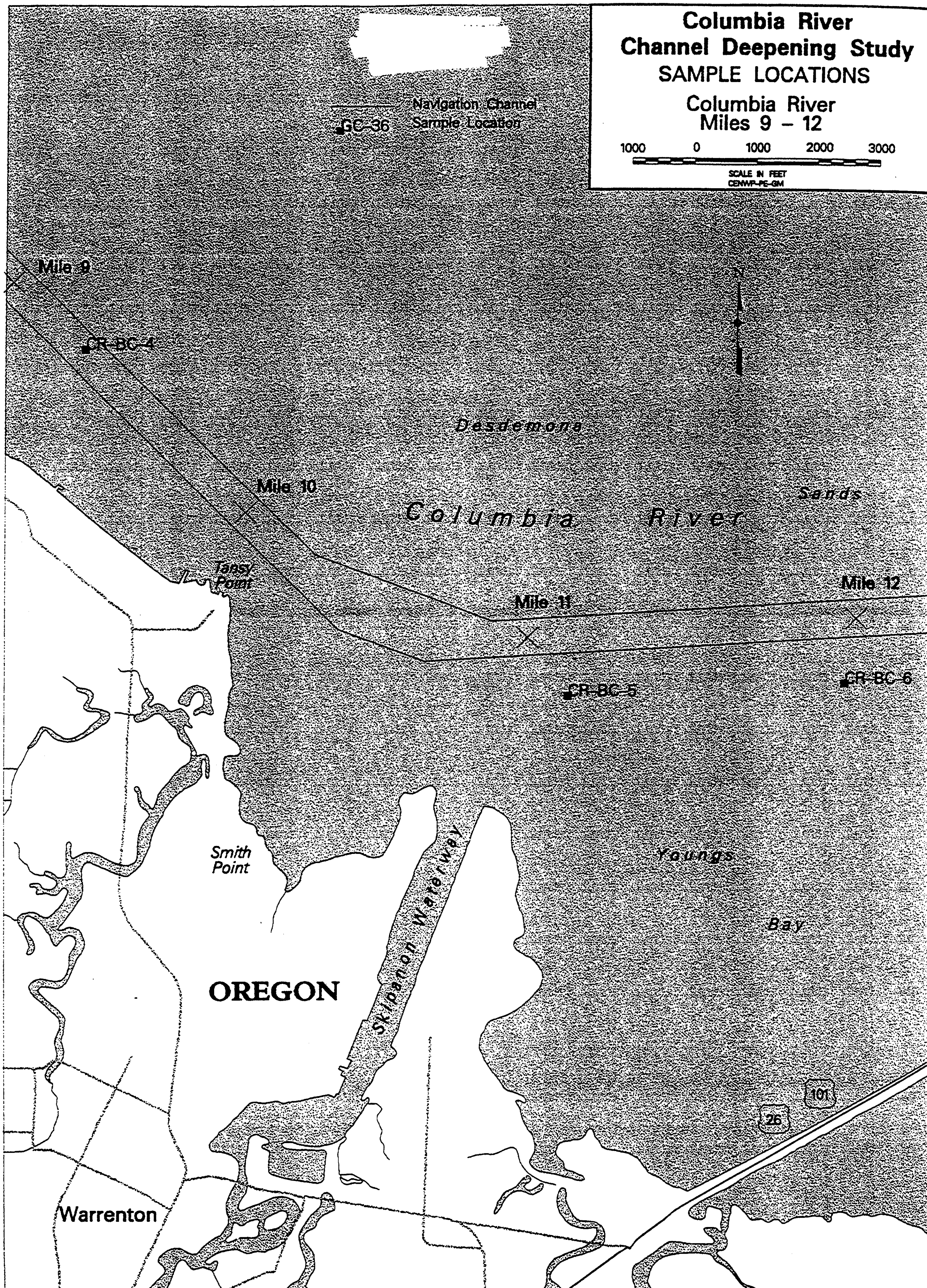
Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 21.5 – 24
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
Sample Location
GC-36
Pigeon Bluff
WASHINGTON
Harrington Point
CR-BC-15
Rice Island
Mile 23
Mile 22
CR-BC-14
Miller Sands
Columbia River
OREGON

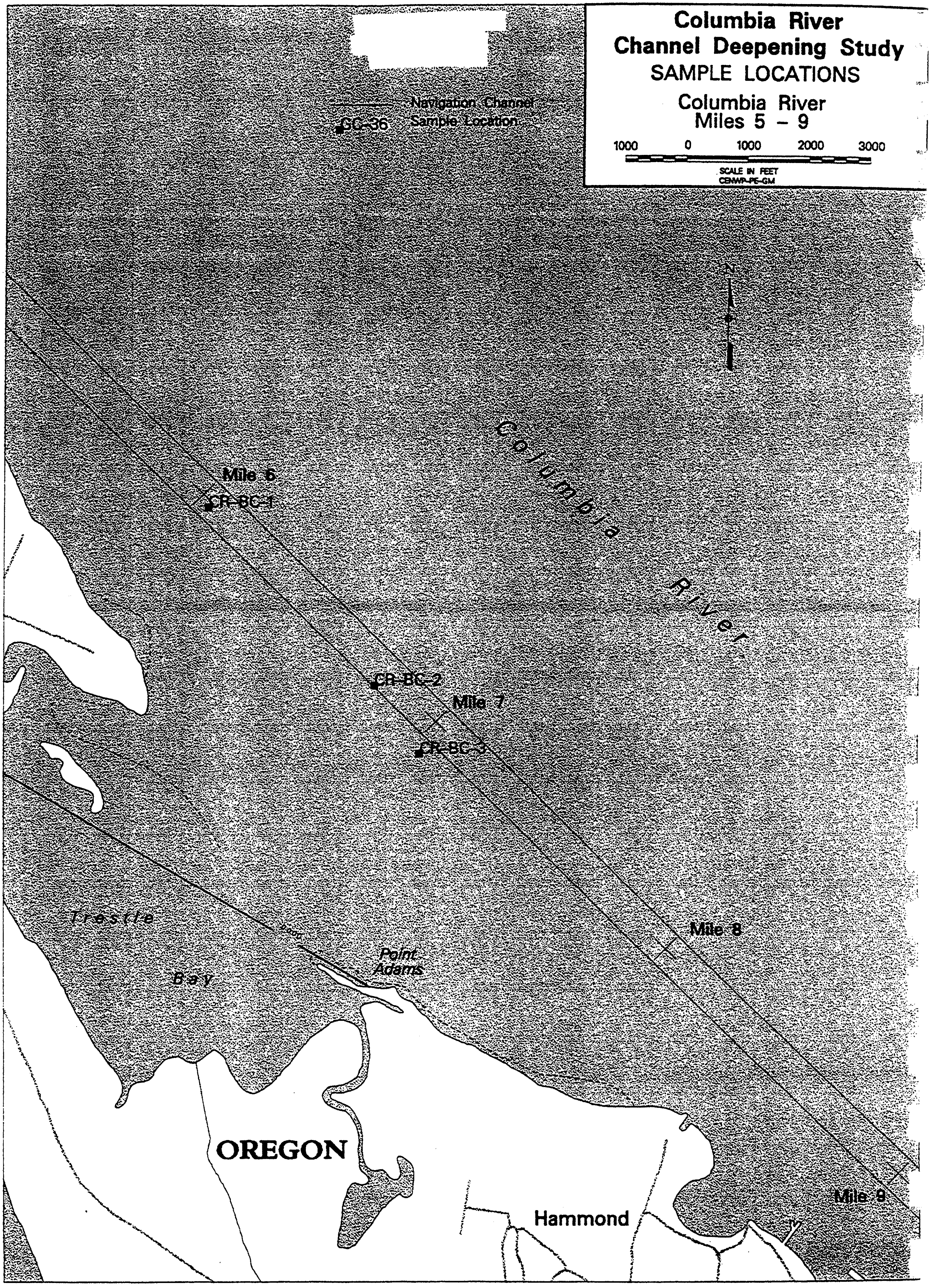

Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 18 - 21
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
GC-36 Sample Location
N
Mile 21
CR-BC-1
Mile 20
CR-BC-12
Mile 19
CR-BC-11
Mile 18
Columbia River
Tongue Point
OREGON
Mott Island
Lois Island


Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 15 - 18
1000
0
1000
2000
3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
GC-36
Sample Location
N
Mile 18
Columbia River
Mile 17
Tongue Point
CR-BC-10
Mile 16
CR-BC-9
Mile 15
Tongue Point Village
Navy Heights
Astoria
OREGON



Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 12 - 15
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
Sample Location
GC-36
101
N
Columbia River
Mile 13
Mile 14
Mile 15
CR-BC-8
CR-BC-7
Smith Point
Astoria
OREGON
101
26
Dagget Point


Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 9 – 12
1000 0 1000 2000 3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
Sample Location
GC-36
N
Mile 9
CR-BC-4
Desdemona
Sands
Mile 10
Columbia River
Tansy Point
Mile 11
Mile 12
CR-BC-5
CR-BC-6
Smith Point
Youngs
Bay
Skipanon Waterway
OREGON
101
26
Warrenton


Columbia River
Channel Deepening Study
SAMPLE LOCATIONS
Columbia River
Miles 5 - 9
1000
0
1000
2000
3000
SCALE IN FEET
CENWP-PE-GM
Navigation Channel
Sample Location
GC-36
N
Columbia River
Mile 6
CR-BC-1
CR-BC-2
Mile 7
CR-BC-3
Trestle
Bay
Point Adams
Mile 8
OREGON
Hammond
Mile 9